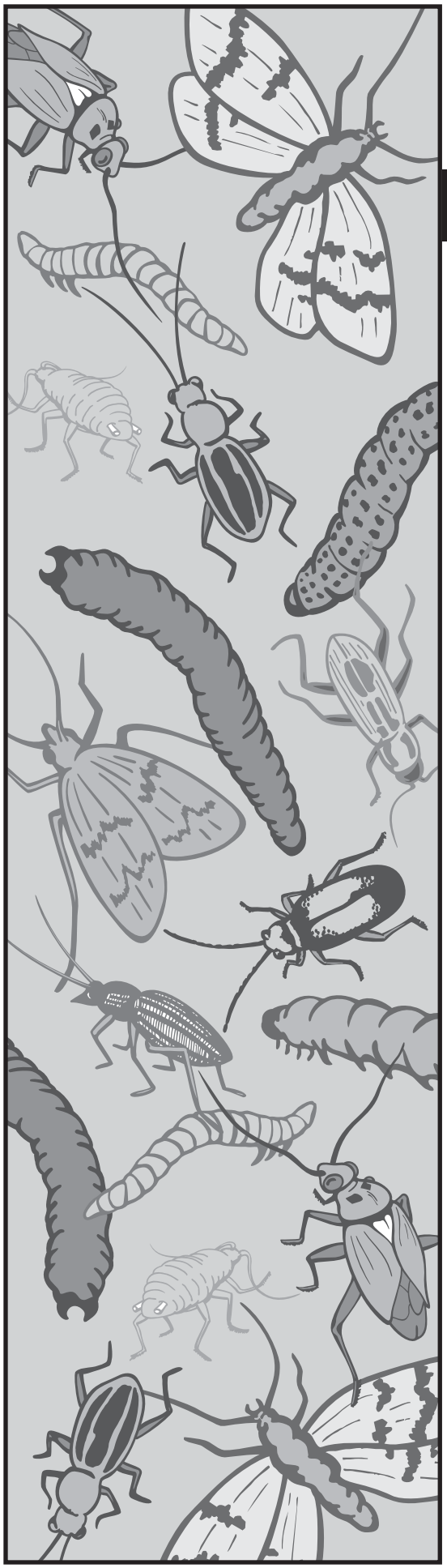

E1143-20 **This Publication Supercedes All Previous Issues**

2020

North Dakota Field Crop Insect Management Guide

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NDSU Crop and Pest Report
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Web Publication
www.ag.ndsu.edu/pubs/plantsci/pests/E1143.pdf

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North DakotaState University
Fargo, North Dakota

E-1143 (Revised)

2020 Field Crop Insect Management Guide

For Use in 2020 Only

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December 2019

This is your reference copy of the 2020 edition of the North Dakota Insect Management Guide. The recommendations conform to the current federal and state laws and regulations relating to pesticidal chemicals at the time of printing. However, because pesticide recommendations frequently are subject to change, and inasmuch as this publication is revised only once each year, keeping in contact with North Dakota State University for up-to-date information on possible changes in insecticide registrations and use patterns is extremely important.

Under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), as amended, using any pesticides in a manner inconsistent with the label is illegal. Therefore, **reading**, **understanding** and **following** all label directions and precautions is of the utmost importance for insecticide users.

Trade names have been used in some cases for simplicity, and their usage does not imply endorsement of one product over another nor discrimination against any product by the North Dakota State University Extension Service. Some compounds have been omitted because they are not available, present unnecessary hazards to the user, or there is a lack of efficacy when compared with other available products.

CAUTION!!!

The Extension Entomology staff at North Dakota State University believes that the recommendations in the guide are essentially accurate. However, since we do not exercise control over their use and the manner or conditions under which they are used, we assume no responsibility for personal injury, property damage or other types of loss resulting from the handling or use of the pesticides listed herein. PLEASE DISCARD ALL EARLIER EDITIONS OF THE NORTH DAKOTA FIELD CROP INSECT MANAGEMENT GUIDE.

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GENERAL INSECTICIDE INFORMATION

The following recommendations include only the application of chemicals for the control of some of the important insect and mite pests for each crop. Keep in mind that the most effective and economial controls for many of these pests involve a complete program including cultural, mechanical and chemical operations.

For more complete information on any particular pest, consult reference material, such as textbooks, bulletins, circulars and leaflets covering the specific problem. North Dakota State University Extension Entomology staff can help you find the most up to date information for a given pest.

Insecticides usually are available as emulsifiable concentrates, wettable powders, dusts, granules or solutions. Each is designed for a specific method of application. For example, dusts are formulated to be applied dry; wettable powders are designed mainly for high gallonage pressure sprayers as used for spraying livestock; emulsifiable concentrates, when diluted with water, form emulsions which may be used in low gallonage, low pressure sprayers. The job to be done and the equipment to be used will govern the type of formulation to recommend.

Amount of Active Ingredient per Acre

Most applications to field crops are made with granular, soluble powder or liquid formulations. The labels for most products listed in this guide give application rates in amount of product per acre or per 1,000 row-feet (for variable row spacings). Seed treatments rates are generally given as amount of product per hundredweight (cwt) or a standard seed unit, such as an 80,000 seed unit for corn, but may also be given in amount of active ingredient (AI) per seed. In addition to total product rates, most insecticide labels also indicate the amount of AI applied for a given total product rate. All insecticide labels list percent AI in the product, as well as the AI amount per unit weight or volume of product, depending on the formulation. This information can be found at the beginning of the product label.

Many insecticides have restrictions on the amount of AI that can be used per acre per season. Different insecticide brands can have different total product application rates (based on different AI concentrations) *even though they have the same AI*. These restrictions are often given in amount of AI per acre per season. Therefore, it is extremely important to understand exactly how much AI is being applied. For example, if a product containing 2 lbs imidacloprid per gallon is applied at a rate of 6 fl oz of product per acre, the amount of AI applied is 0.078 lbs imidacloprid per acre

(2 lbs/gal x 1 gal/128 fl oz x 6 fl oz/acre).

If a product containing 4 lbs imidacloprid per gallon is applied at a rate of 3 fl oz per acre, *the same amount of AI is applied as with the 2 lb per gallon product at 6 fl oz per acre*. Some products contain more than one AI, but the same restrictions on use for each AI per acre per season still apply.

Understanding product composition and the relationship between AI concentration in a product and total product application rate also assists growers and applicators in deciding which products are of optimum safety and benefit in their farming operations.

Pesticide Residue Tolerance

Pesticide residue limits in feed, food and food products are set by the Environmental Protection Agency (EPA), as required by the Federal Food, Drug, and Cosmetic Act amended to include the Food Quality Protection Act. These limits are known as tolerances, and are set to protect the nation's food supply and its consumers from harmful levels of pesticide residues. For more information on tolerances, please visit www.epa.gov/pesticides

Preharvest Intervals

A preharvest interval is the time required between applications and harvest which will ensure conformance with with tolerance limits. Preharvest intervals vary among products. Also, restrictions are often placed on grazing, foraging, and harvesting hay and straw. In some instances, a product cannot be used simply because it is not possible to adhere to the preharvest interval. In this guide, preharvest intervals for all products are given for each crop. Where applicable, grazing, forage, hay and straw harvest intervals and restrictions are also given. **Be sure to consult the product label you are using at the time of application for all preharvest and grazing restrictions.**

INSECTICIDE FORMULATION ABBREVIATIONS

CF	capsule suspension for seed treatment	EW	emulsion, oil in water	ULV	ultra-low volume
CG	encapsulated granule	F	flowable	WDG	water dispersable granules
CS	capsule suspension	FL	flowable	WP	wettable powder
D	dry	FS	flowable concentrate for seed treatment	WSP	water dispersable powder
DC	dispersible concentrate	GR	granule	XL	other liquid formulation
DF	dry flowable	L	liquid	XX	others
DP	dustable powder	LS	solution for seed treatment	ZC	mixed formulation of CS and SC
DS	dry seed treatment	ME	microemulsion		
E	emulsifiable	OD	oil dispersion		
EC	emulsifiable concentrate	OS	oil-based suspension concentrate		
EG	emulsifiable granule	SC	suspension concentrate		
EP	emulsifiable powder	SL	soluble concentrate		

ES emulsion for seed treatment SP soluble powder

INSECTICIDE CLASSES AND RESISTANCE MANAGEMENT

Insecticides can be classified in a number of ways. The following table provides a listing of insecticides included in the crop sections of this guide registered for use in North Dakota. Be sure to consult the North Dakota Department of Agriculture for current product registration. Product labels and material safety data sheets (MSDS) in electronic form can be searched, viewed and printed from the Kelly Registration Systems website: www.kellysolutions.com/nd This website can also be accessed from the Pesticide Registration Program webpage in the North Dakota Department of Agriculture website: www.nd.gov/ndda/program/pesticide-registration-program Product cancellations and/or new product registrations will be updated in the on-line version of this guide.

Alternating the class of insecticide used for controlling insects can delay or even prevent insects becoming resistant to those chemicals. Reliance on a single chemical or a group of chemicals in the same insecticide class can lead to development of resistance at a faster rate. Resistance develops when exposed survivors of a chemical application are able to reproduce and pass on to their offspring the genetic traits responsible for their survival. If control failure occurs and cannot be attributed to equipment malfunction, human error or environmental conditions, do not use that chemical or another chemical in the same class in a follow-up treatment.

Even when control failure does not occur, rotation of insecticide classes should be observed within a season, and from year to year if possible. This is particularly true for foliar applications following use of seed treatments. Many seed treatments, such as imidacloprid and thiamethoxam, are from the neonicotinoid class of insecticides. These same chemicals are also the AIs in products labeled for foliar application in the same crops. Many labels contain Resistance Management language in the labels. Recently, many product labels include the Insecticide Resistance Action Committee (IRAC) Groups number in the upper right corner of the label. This number indicates the chemical class to which the product belongs, and its mode of action. For more information, please visit the IRAC website at: www.irac-online.org

Trade Name	Active Ingredient	Class	IRAC Group
ABBA 0.15EC	abamectin	A	6
Acephate 75WSP	acephate	OP	1B
Acephate 90 Prill	acephate	OP	1B
Acephate 90WDG	acephate	OP	1B
Acephate 97	acephate	OP	1B
Acephate 97UP	acephate	OP	1B
Acramite 4SC	bifenazate	BI	20D
Actara	thiamethoxam	N	4A
ADAMA Alias 2F	imidacloprid	N	4A
ADAMA Alias 4F	imidacloprid	N	4A
Admire Pro	imidacloprid	N	4A
Advise Four	imidacloprid	N	4A
Agri-Mek 0.15EC	abamectin	A	6
Agri-Mek SC	abamectin	A	6
Ambush	permethrin	P	3A
Ambush 25W	permethrin	P	3A
AmTide Imidacloprid 2F	imidacloprid	N	4A
Arctic 3.2EC	permethrin	P	3A
Asana XL	esfenvalerate	P	3A
Assail 30SG	acetamiprid	N	4A
Athena	abamectin bifenthrin	A+P	6 3A
Attendant 480 FS	imidacloprid	N	4A
Attendant 600	imidacloprid	N	4A
Avaunt	indoxacarb	IN	22A
Avicta 500 FS	abamectin thiamethoxam	A+N	6 4A
Avicta Complete Beans 500	abamectin thiamethoxam	A+N	6 4A
Avicta Duo Corn	abamectin thiamethoxam	A+N	6 4A
Aztec 2.1G	cyfluthrin tebupirimiphos	P+OP	3A 1B
Aztec 4.67G	cyfluthrin tebupirimiphos	P+OP	3A 1B
Baythoid XL	beta-cyfluthrin	P	3A
Belay	clothianidin	N	4A

Trade Name	Active Ingredient	Class	IRAC Group
Beleaf 50G	flonicamid	FL	29
Besiege	chlorantraniliprole lambda-cyhalothrin	D+P	28 3A
Bifen 2 AG Gold	bifenthrin	P	3A
Bifender FC	bifenthrin	P	3A
Bifenthrin 2EC	bifenthrin	P	3A
Bifenture EC	bifenthrin	P	3A
Biobit HP	Bt	M	11A
Blackhawk	spinosad	S	5
Brigade 2EC	bifenthrin	P	3A
Brigadier	bifenthrin imidacloprid	P+N	3A 4A
Capture LFR	bifenthrin	P	3A
Cheminova Malathion 57%	malathion	OP	1B
Centynal	deltamethrin	P	3A
Chlorpyrifos 4E AG	chlorpyrifos	OP	1B
Clariva Elite Beans	thiamethoxam	N	4A
Cobalt Advanced	chlorpyrifos lambda-cyhalothrin	OP+P	1B 3A
Coragen	chlorantraniliprole	D	28
Counter 15G Lock n' Load	terbufos	OP	1B
Counter 20G SmartBox	terbufos	OP	1B
Cruiser 5FS	thiamethoxam	N	4A
Cruiser Maxx	thiamethoxam	N	4A
Cruiser Maxx Cereals	thiamethoxam	N	4A
Cruiser Maxx Potato	thiamethoxam	N	4A
Cruiser Maxx Vibrance	thiamethoxam	N	4A
Cruiser Maxx Vibrance Cereals	thiamethoxam	N	4A
Cruiser Maxx Vibrance Potato	thiamethoxam	N	4A

Trade Name	Active Ingredient	Class	IRAC Group
Cruiser Maxx Vibrance Pulses	thiamethoxam	N	4A
Declare	gamma-cyhalothrin	P	3A
Delta Gold	deltamethrin	P	3A
Diacon-D IGR	methoprene	JH	7A
Diacon IGR	methoprene	JH	7A
Dibrom 8 Emulsive	naled	OP	1B
Dimate 4E	dimethoate	OP	1B
Dimethoate 400	dimethoate	OP	1B
Dimethoate 4E	dimethoate	OP	1B
Dimethoate 4EC	dimethoate	OP	1B
Dimilin 2L	diflubenzuron	B	15
DiPel DF	Bt	M	11A
DiPel ES	Bt	M	11A
Discipline 2EC	bifenthrin	P	3A
Dyna-Shield Imidacloprid 5	imidacloprid	N	4A
Endigo ZC	lambda-cyhalothrin thiamethoxam	P+N	3A 4A
Enhance AW	imidacloprid	N	4A
Entrust	spinosad	S	5
Epi-Mek 0.15EC	abamectin	A	6
Ethos LFR	bifenthrin	P	3A
Ethos XB	bifenthrin	P	3A
Exirel	cyantraniliprole	D	28
Fanfare 2EC	bifenthrin	P	3A
Fastac CS	alpha-cypermethrin	P	3A
Fastac EC	alpha-cypermethrin	P	3A
Foothold Extra	imidacloprid	N	4A
Foothold Virock	imidacloprid	N	4A
Force 3G	tefluthrin	P	3A
Force 3G SmartBox	tefluthrin	P	3A
Force 6.5G	tefluthrin	P	3A
Force Evo	tefluthrin	P	3A
Fortenza	cyantraniliprole	D	28
Fulfill	pymetrozine	PA	9B
Fyfanon ULV AG	malathion	OP	1B
Gaucho 600	imidacloprid	N	4A
Govern 4E	chlorpyrifos	OP	1B
Grizzly Too	lambda-cyhalothrin	P	3A
Hatchet	chlorpyrifos	OP	1B
Helix Vibrance	thiamethoxam	N	4A
Helix XTra	thiamethoxam	N	4A
Hero	bifenthrin zeta-cypermethrin	P	3A 3A
Imidan 70W	phosmet	OP	1B
Inovate System	clothianidin	N	4A
Intego SUITE Cereals OF	clothianidin	N	4A
Intego SUITE Soybeans	clothianidin	N	4A
Intrepid 2F	methoxyfenozide	DH	18
Kendo	lambda-cyhalothrin	P	3A
Kernel-Guard Supreme	permethrin	P	3A
Lambda-Cy EC	lambda-cyhalothrin	P	3A
LambdaStar	lambda-cyhalothrin	P	3A
Lambda-T	lambda-cyhalothrin	P	3A
Lamcap	lambda-cyhalothrin	P	3A
Lannate LV	methomyl	C	1A

Trade Name	Active Ingredient	Class	IRAC Group
Leverage 360	beta-cyfluthrin imidacloprid	P+N	3A 4A
Lorsban 15G	chlorpyrifos	OP	1B
Lorsban 4E	chlorpyrifos	OP	1B
Lorsban 50WSP	chlorpyrifos	OP	1B
Lorsban Advanced	chlorpyrifos	OP	1B
Lumiderm	cyantraniliprole	D	28
Malathion 5	malathion	OP	1B
Malathion 57EC	malathion	OP	1B
Malice 2F	imidacloprid	N	4A
Malice 75WSP	imidacloprid	N	4A
Match-Up	chlorpyrifos bifenthrin	OP+P	1B 3A
Minecto Pro	cyantraniliprole abamectin	D+A	28 6
Montana 2F	imidacloprid	N	4A
Montana 4F	imidacloprid	N	4A
Movento	spirotetramat	TA	23
Movento HL	spirotetramat	TA	23
Mustang Maxx	zeta-cypermethrin	P	3A
NipsIt Inside	clothianidin	N	4A
NipsIt SUITE Cereals OF	clothianidin	N	4A
NipsIt SUITE Sugar Beets	clothianidin	N	4A
Nufarm Abamectin 0.15EC	abamectin	A	6
Nufarm Lambda-Cyhalothrin 1EC	lambda-cyhalothrin	P	3A
Nufos 4E	chlorpyrifos	OP	1B
Nuprid 2SC	imidacloprid	N	4A
Nuprid 4.6F Pro	imidacloprid	N	4A
Nuprid 4F Max	imidacloprid	N	4A
Oberon 2SC	spiromesifen	TA	23
Paradigm VC			
Pasada 1.6F	imidacloprid	N	4A
PermaStar AG	permethrin	P	3A
Permethrin 3.2EC	permethrin	P	3A
Perm-UP 3.2EC	permethrin	P	3A
Platinum	thiamethoxam	N	4A
Platinum 75SG	thiamethoxam	N	4A
Poncho 600	clothianidin	N	4A
Poncho Beta	clothianidin beta-cyfluthrin	N+P	4A 3A
Poncho Votivo	clothianidin *Bacillus firmus*	N	4A
Pounce 1.5G	permethrin	P	3A
Precept	tefluthrin	P	3A
Prevathon	chlorantraniliprole	D	28
Prey 1.6F	imidacloprid	N	4A
Prosper EverGol	clothianidin	N	4A
Province	lambda-cyhalothrin	P	3A
Radiant SC	spinetoram	S	5
Rancona Crest	imidacloprid	N	4A
Rancona Crest WR	imidacloprid	N	4A
Raxil PRO Shield	imidacloprid	N	4A
Reaper 0.15EC	abamectin	A	6
Regent 4SC	fipronil	PP	2B
Rimon 0.83EC	novaluron	B	15
Sativa IM Max	imidacloprid	N	4A
Scorpion 35SL	dinotefuran	N	4A

Trade Name	Active Ingredient	Class	IRAC Group
Sefina	afidopyropen	PY	9D
Senator 600FS	imidacloprid	N	4A
Sevin 4F	carbaryl	C	1A
Sevin SL	carbaryl	C	1A
Sevin XLR Plus	carbaryl	C	1A
Sherpa	imidacloprid	N	4A
Silencer	lambda-cyhalothrin	P	3A
Silencer VXN	lambda-cyhalothrin	P	3A
Sivanto Prime	flupyradifurone	BU	4D
Skyraider	bifenthrin imidacloprid	P+N	3A 4A
SmartChoice 5G Lock n' Load	bifenthrin chlorethoxyfos	P+OP	3A 1B
Sniper	bifenthrin	P	3A
Sniper Helios	bifenthrin	P	3A
Sniper LFR	bifenthrin	P	3A
Spintor 2SC	spinosad	S	5
Stallion	chlorpyrifos zeta-cypermethrin	OP+P	1B 3A
Steward EC	indoxacarb	O	22A
Success Optim	spinosad	S	5
Swagger	bifenthrin imidacloprid	P+N	3A 4A
Thimet 20G Lock n' Load	phorate	OP	1B
Thimet 20G SmartBox	phorate	OP	1B
Timectin 0.15EC	abamectin	A	6
Tombstone	cyfluthrin	P	3A
Tombstone Helios	cyfluthrin	P	3A

Trade Name	Active Ingredient	Class	IRAC Group
Torac	tolfenpyrad	METI	21A
Tracer	spinosad	S	5
Transform WG	sulfoxaflor	SU	4C
Tundra EC	bifenthrin	P	3A
Tundra Supreme	bifenthrin chlorpyrifos	P+OP	3A 1B
Upshot Soybeans	thiamethoxam	N	4A
Venom	dinotefuran	N	4A
Vulcan	chlorpyrifos	OP	1B
Vydate C-LV	oxamyl	C	1A
Vydate L	oxamyl	C	1A
Warden Cereals 360	thiamethoxam	N	4A
Warden Cereals HR	imidacloprid	N	4A
Warden Cereals WR II	thiamethoxam	N	4A
Warden CX	thiamethoxam	N	4A
Warhawk	chlorpyrifos	OP	1B
Warrior II	lambda-cyhalothrin	P	3A
Whirlwind	chlorpyrifos	OP	1B
Widow	imidacloprid	N	4A
Wrangler	imidacloprid	N	4A
Xentari DF	Bt	M	11A
Yuma 4E	chlorpyrifos	OP	1B
Zeal SC	etoxazole	E	10B
Zeal WDG	etoxazole	E	10B

Chemical Class Abbreviations: A = avermectins; B = benzoylureas; BI = bifenazate; BU = butenolides; C = carbamates; D = diamides; DH = diacylhydrazines; E = etoxazole; FL = flonicamid; IM = inhibitors of mitochondrial ATP synthase; IN = indoxacarb; JH = juvenile hormone analogues; M = microbial disruptors of insect midgut membranes; METI = mitochondrial electron transport inhibitors; N = neonicotinoid; OP = organophosphates; P = pyrethroids; PA = pyridine azomethine derivatives; PC = pyridine carboxamides; PP = phenylpyrazoles; PY = pyropenes; S = spinosyns; SU = sulfoximines; TA = tetronic and tetramic acid derivatives

IRAC Group Modes of Action: 1A, 1B = acetyl cholinesterase inihibitors; 2B = GABA-gated chloride channel blockers; 3A = sodium channel modulators; 4A, 4C, 4D = nicotinic acetylcholine receptor competitive modulators; 5 = nicotinic acetylcholine receptor allosteric modulators; 6 = glutamate-gated chloride channel allosteric modulators; 7A = juvenile hormone mimics; 9B, 9D = chordotonal organ TRPV channel modulators; 10B mite growth inhibitors; 11A = microbial disruptors of insect midgut membranes (includes Bt transgenic crops); 12C = inhibitors of mitochondrial ATP synthase; 15 = inhibitors of chitin biosynthesis, type 0; 18 = ecdysone agonists; 20D = mitochondrial complex III electron transport inihibitors; 21A = mitochondrial complex I electron transport inhibitors; 22A = voltage-dependent sodium channel blockers; 23 = inhibitors of acetyl CoA carboxylase; 28 = ryanodine receptor modulators; 29 = chordotonal organ modulators (undefined target site); UN = unknown mode of action

INSECTICIDE TOXICITY

All insecticides are classified as poisons, although there is considerable variation in their degrees of toxicity to warm-blooded animals and fish. Toxicity refers to the degree to which a specific chemical is poisonous to animals. Toxicity is classified as **acute** (severe, immediate toxicity) or **chronic** (long-term).

Poisoning from insecticides can occur through the eyes, ears, mouth and nose (oral), lungs (inhalation) and/or skin (dermal). Storing, handling, mixing, loading and applying insecticides and working in treated areas inherently poses occupational hazards from poisoning, especially poisoning via inhalation and skin contamination. All insecticide labels have language relating to worker safety, specifically the Worker Protection Standard, 40 CFR part 170. This information can be found in the **AGRICULTURAL USE REQUIREMENTS** section at the beginning of the label. The language in this section contains the restricted entry interval (REI), posting requirements for treated areas and the minimum personal protective equipment (PPE) required for permitted early entry into treated areas. For more information on the Worker Protection Standard, please visit the EPA website at:

http://www.epa.gov/agriculture/twor.html

Additionally, labels carry **PRECAUTIONARY STATEMENTS** language that must be followed regarding PPE when handling, mixing, loading and/or applying pesticides. Labels also carry an **ENVIRONMENTAL HAZARDS** section, which contains language relating to application to or near surface water and other environmentally sensitive areas, spray drift and runoff language, and bee exposure language. **DIRECTIONS FOR USE, PHYSICAL AND CHEMICAL HAZARDS,** and **STORAGE AND DISPOSAL** sections provide additional safety language. Labels also carry a **FIRST AID** section describing what steps need to be taken in case of exposure.

Insecticide labels carry signal words indicating human toxicity. Tests used to determine insecticide toxicity involve laboratory animals. Toxicity is most commonly expressed as LD_{50}, which means the lethal dose required to kill 50 percent of the test animal population. The amount of material needed to produce a lethal dose is expressed as milligrams of toxicant per kilogram of live animal weight (mg/kg). LD_{50} values are determined for oral, inhalation, and dermal poisoning. Specific toxicological information for a pesticide is given in its **Material Safety Data Sheet (MSDS)**. The table below gives the EPA toxicity categories, signal words and acute oral LD_{50} values for each toxicity catergory.

Category	Toxicity	Signal Word	Acute Oral LD_{50}
1	Highly toxic	Danger-Poison (accompanied by skull and crossbones)	< 50 mg/kg
2	Moderately toxic	Warning	50 to 500 mg/kg
3	Slightly toxic	Caution	501 to 5,000 mg/kg
4	Low toxicity	Caution	> 5,000 mg/kg

Pesticide Poison Information
Toll-Free Number (800) 222-1222

THE EFFECT OF WATER PH ON INSECTICIDES

An important consideration in the application of insectides is the pH of the water to be used for spraying. This is particularly important for carbamate and organophosphate insecticides. When mixed with water, the active ingredients undergo a process called alkaline hydrolysis. If left in the solution too long, including while in the spray tank and in spray droplets, these chemicals will degrade and become ineffective. For these chemicals, a buffering agent should be added to the water to adjust the pH to the proper level. Buffering effects occur until the water in the applied spray droplets has evaporated.

Values for pH are given on a scale from 1 to 14, with 1 being most acidic and 14 being most basic. A pH of 7 is considered neutral. Water pH values in the Red River Valley are slightly basic (pH around 8 - 8.2). The pH of the water being used for spraying should be tested with an electronic pH meter. Do not use paper testing strips, as these can be inaccurate.

The table below gives the optimum pH values for the spray tank water to be used for common insecticide active ingredients, as well as the half-life for each at different pH levels and whether a buffering agent should be used. Buffering agents can be obtained from your chemical supplier. Another important consideration is whether the insecticide will be tank-mixed with an herbicide or fungicide. Herbicides and fungicides also have optimum pH values, and some of these may be incompatible with some insecticides. Fixed copper fungicides and lime or lime sulfur should not be buffered, as plant injury can result.

Half-life of Some Commonly Used Insecticides at Different Water pH

				Half-life for Given pH at 25°C in Pure Water				
Insecticide Active Ingredient	**Example Trade Name**	**Buffering Advised**	**Optimum pH**	**9.0**	**8.0**	**7.0**	**5.0**	**4.0**
abamectin	Epi-Mek 0.15EC		7.0	Stable		Stable	Stable	
acephate	Acephate 97UP		7.0	16 d		46 d	40 d	
acetamiprid	Assail 30SG		7.0	Stable		Stable	Stable	
beta-cyfluthrin	Baythroid XL		7.0	17 h		Stable	Stable	Stable
bifenthrin	Bifenture EC		7.0	Stable		Stable	Stable	
carbaryl	Sevin 4F	●	7.0	3.2 h		12 d	Stable	
chlorantraniliprole	Coragen		7.0	< 10 d		Stable	Stable	

chlorpyrifos	Lorsban 4E		7.0	16 d		35 d	63 d	
clothianidin	Belay		7.0	Stable		Stable	Stable	
cyfluthrin	Tombstone		7.0	2 d	4 d	Stable	Stable	
deltamethrin	Delta Gold		7.0	2.5 d	31 d	Stable	Stable	
dimethoate	Dimate 4E	●	7.0	4 d		68 d	156 d	
esfenvalerate	Asana XL		7.0	Stable		Stable	Stable	
gamma-cyhalothrin	Declare		7.0	9 d		Stable	Stable	
imidacloprid	Admire Pro		7.0	Stable		Stable	Stable	
indoxacarb	Steward EC		7.0	1 day		38 d	30 d	
lambda-cyhalothrin	Warrior II		7.0	9 d		Stable	Stable	
malathion	Malathion 57EC	●	5.0	5 h	19 h	3 d	150 d	
methomyl	Lannate LV		7.0	Stable		Stable	Stable	
naled	Dibrom	●	5.0	1.6 h		15.4 h	4 d	
oxamyl	Vydate	●	5.0	3 hrs		8 d	Stable	
permethrin	Arctic 3.2EC		7.0	242 d		Stable	Stable	
phosmet	Imidan 70W	●	5.0	4 h		18 h	9 d	
spinosad	Spintor 2SC	●	7.0	Stable		Stable	12 h	
thiamethoxam	Actara		7.0	2 d		29 d		14 d
zeta-cypermethrin	Mustang Maxx		7.0	2 d		Stable	Stable	

d = days, h = hours

MANAGING INSECTICIDES TO PREVENT GROUNDWATER CONTAMINATION

The potential for insecticide movement into groundwater exists wherever insecticides are used, but the extent varies with the chemical nature of the insecticide, physical soil characteristics and other factors such as volatilization (with subsequent loss to the atmosphere), decomposition, soil retention and transport by water. Volatilization, decomposition and soil retention reduce the total amounts of insecticides available for downward movement. Transport by water relates to the movement of insecticides with soil water.

The amount of insecticide applied affects the potential for groundwater contamination. The potential movement to groundwater of relatively mobile water-soluble insecticides may be much increased where large amounts have entered the soild, such as areas used for tank filling, rinsing and equipment washing. These practices should be carried out on concrete or other impermeable pads, and the liquid should be collected for disposal.

Organophosphorous, carbamate, pyrethroid and neonicotinoid insecticides present a wide spectrum of physiochemical properties and agricultural uses. Breakdown of insecticides in soil is caused by hydrolysis from water and microbes, and by reaction with light (photolysis). Soil half-life is greatly affected by physical properties of the soil, such as soil type, the amount of organic matter in the soil, the amount of water in the soil column, and soil pH. For example, the half-life of chlorpyrifos in soil typically ranges from 60 to 120 days, but can be as low as two weeks or as long as one year.

Neonicotinoids are a relatively new class of insecticides, and may be applied as foliar sprays and/or seed treatments. Generally, neonicotinoids are highly mobile and relatively persistent in soil. However, plant uptake of neonicotinoids used as seed treatments and foliar sprays reduces the potential for groundwater contamination.

The following table gives the relative persistence and mobility of some insecticides commonly used in North Dakota. Bear in mind that the persistence and mobility classification assigned to each insecticide is approximate because environmental variation will influence persistence and mobility. Whenever several insecticide options exist for the pest/site to be treated, this information will help pesticide users and advisors select the insecticide that presents the least potential for groundwater contamination. More information on the environmental fate of insecticides can be found at:

FAO specifications and evaluations for plant protection products: http://www.fao.org

Extension Toxicology Network: http://pmep.cce.cornell.edu/profiles/extoxnet

Relative Persistence and Mobility of Insecticides in Soils

AI	Persistence[1]	Mobility[2]
abamectin	L	NI
acephate	M	VM
acetamiprid	L	MM
beta-cyfluthrin	L	NI
bifenthrin	M	NI
carbaryl	L	NI
chlorantraniliprole	M	VM
chlorpyrifos	L	NI
clothianidin	M	SM
cyfluthrin	L	NI
deltamethrin	L	NI
dimethoate	L	MM
esfenvalerate	M	I
fipronil	M	SM
gamma-cyhalothrin	M	NI
imidacloprid	M	MM
indoxacarb	M	NI
lambda-cyhalothrin	M	NI
malathion	L	NI
methomyl	L	SM
naled	L	SM
oxamyl	L	VM
permethrin	L	I
phorate	L	NI
phosmet	L	NI
spinosad	L	I
tefluthrin	L	NI
terbufos	M	SM
thiamethoxam	M	VM

zeta-cypermethrin	M	NI

[1] L = low persistence; M = moderate persistence
[2] I = immobile; NI = nearly immobile; SM = slightly mobile; MM = moderately mobile; VM = very mobile

Summary of Groundwater Contamination Potential as Influenced by Pesticide, Water and Soil Characteristics

	Low Risk	High Risk
Pesticide Characteristics		
water solubility	low	high
soil adsorption	high	low
persistence	low	moderate to high
Soil Characteristics		
texture	fine clay	coarse sand
organic matter	high	low
macropores	few, small	many, large
water table	deep (20+ ft)	shallow (< 10 ft)
Water Volume		
rain/irrigation	small volumes at	large volumes at frequent intervals
	infrequent intervals	

Measures to protect groundwater from pesticides generally involve the following:

- Reduce the quantity of pesticide used
- Use pesticides with low soil leaching potential
- Use pesticides that have low persistence
- Avoid application if conditions favor leaching
- Prevent spills which can leach to groundwater
- Prevent back-siphoning to water source

Protecting Your Groundwater Through Farmstead Assessment: There are several NDSU Extension publications, which address the issue of protecting groundwater from agricultural pesticides. Access to these circulars can be found at:

https://www.ag.ndsu.edu/publications/environment-natural-resources/a-guide-to-plugging-abandoned-wells

https://www.ag.ndsu.edu/publications/environment-natural-resources/protecting-groundwater-from-pesticide-contamination

NORTH DAKOTA FIELD POSTING REQUIREMENTS

Effective July 1, 2004, North Dakota no longer has additional posting requirements for pesticides that are more demanding than federal labeling requirements. However, all pesticides that require posting on the label under the Worker Protection Standard must be posted according to the Worker Protection Standard.

REPORTING DAMAGE DUE TO PESTICIDE APPLICATIONS

Effective April 3, 2007

AN ACT to create and enact a new section to chapter 4-35 of the North Dakota Century Code, rleating to notification of alleged pesticide damage; to repeal sections 4-35-21, 4-35-21.1, and 4-35-21.2 of the North Dakota Century Code, relating to reports of loss resulting from pesticide application; and to declare an emergency.

A new section to chapter 4-35 of the North Dakota Century Code is created an enacted as follows:

Pesticide Application, Alleged Property Damage, Notification of Applicator.

1. a. Before a person may file a civil action seeking reimbursement for property damage allegedly stemming from the application of a pesticide, the person shall notify by certified mail the pesticide applicator of the alleged damage within the earlier of:
(1) Twenty-eight days from the date the person first knew or should have known of the alleged damage; or
(2) Before twenty percent of the crop or field allegedly damaged is harvested or destroyed.
1. b. Subdivision (a) does not apply if the person seeking reimbursement for property damage was the applicator of the pesticide.

2. Upon notifying the applicator as required under subsection 1, the person seeking reimbursement for the alleged property damage shall permit the applicator and up to four representatives of the applicator to enter the person's property for the purpose of observing and examining the alleged damage. If the person fails to allow entry, the person is barred from asserting a claim against the applicator.

SECTION 2. REPEAL. Sections 4-35-21, 4-35-21.1, and 4-35-21.2 of the North Dakota Century Code are repealed.
SECTION 3. EMERGENCY. This Act is declared to be an emergency measure.

Further inquiries shoud be directed to:

North Dakota Department of Agriculture
State Capitol Building
Bismarck, North Dakota 58505
Phone: 1-800-242-7535

https://www.nd.gov/ndda/

INSECTICIDE SEED TREATMENTS

Seed and planter box treatments are used on a wide variety of North Dakota crops for protection from a variety of soil and foliage feeding insects. The following table lists seed treatments and indicates labeled crops. Consult individual crop sections in this guide for active ingredients, product rates, commercial and on-farm use and restrictions on use. Always follow label directions. Protective clothing and equipment for mixing and handling are specified of the label. Mix thoroughly to ensure adequate coverage and protection. Treat only enough seed needed for immediate use. Do not store treated seed near feed or foodstuffs. Do not feed treated seed to livestock. Dispose of excess treated seed as specified on the label.

Slurry Seed Treatment: Seed treatments may be applied as slurry as seed is being augered into a drill, planter or truck. The treating equipment meters chemical into an auger conveyor where it is mixed with seed. The equipment is designed to mount to a truck be, bin or transport augers and drill fill augers. Treaters consist of a metered pump, hoses and tank. The equipment is commonly used in bulk seed operations, providing uniform application of chemical to seed which enhances seed treatment performance.

Planter Box Treatment: Seed treatments should be thoroughly mixed with seed to ensure sufficient coverage. Recommendations for maximizing the effectiveness of planter box seed treatments are as follows:

1. Fill planter box half full of seed
2. Add half of required amount of product and mix thoroughly with a paddle
3. Add remainder of seed and product to the planter box
4. Mix well. Thorough coverage is essential
5. At end of day, clean planter population monitors

Inoculants in Combination with Seed Treatments: Do not confuse seed inoculation with chemical seed treatment. Most seed disinfectants, including fungicides are toxic to *Rhizobium* bacteria. Do not apply inoculum to seeds that are treated with a bactericide, such as streptomycin, unless you use a resistant strain of *Rhizobium*. Although some *Rhizobium* species are slightly tolerant to certain chemical compounds, inoculating chemically treated legume seed requires special precautions. Check with the inoculum manufacturer regarding compatibility when considering combining products.

The following are some general guidelines when using seed treatments and inoculants:

- Insecticides are more toxic than fungicides, which are more toxic than herbicides
- In-furrow inoculant applications are preferred when seed treatments have been used
- If a seed treatment and inoculant are combined on the seed, minimize exposure time; less than 4 hours is best. Some *Rhizobium* may be killed immediately; check compatibility prior to use.
- If liquid pesticides are used, apply first and allow to dry before inoculant is applied
- Powder-based inoculants protect *Rhizobium* better than liquid-based inoculants
- When using pre-treated seed, check with the inoculant manufacturer for comments on compatibility

REGISTERED SEED TREATMENTS APPROVED BY CROP

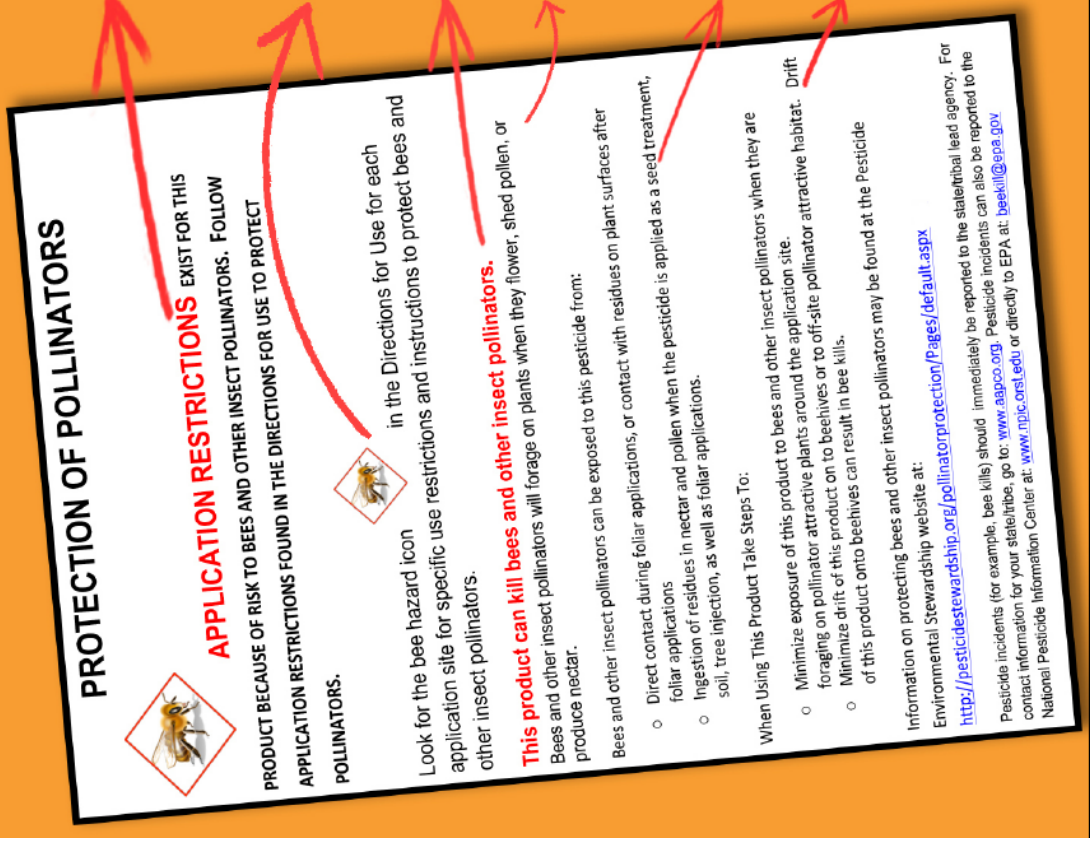
Seed Treatment	Barley	Dry Beans	Canola	Carrot	Chickpea	Corn	Field Pea	Flax	Lentil	Mustard	Oats	Potato	Safflower	Soybean	Sugarbeet	Sunflower	Wheat
Planter Box Treaments																	
Kernel Guard Supreme						●								●			
Commercial and On-Farm Seed Treatments[1]																	
Admire Pro												●					
Advise Four												●					
AmTide Imidacloprid 2F												●					
Attendant 480 FS	●	●	●	●	●		●		●		●			●	●		●
Attendant 600	●	●		●	●	●	●		●	●	●			●			●
Avicta Complete Beans 500														●			
Avicta Complete Corn						●											
Belay												●					
Clariva Elite Beans														●			
Cruiser 5FS	●	●			●	●	●	●	●	●		●	●	●	●	●	●
Cruiser Maxx		●			●		●		●					●			
Cruiser Maxx Cereals	●																●
Cruiser Maxx Potato												●					
Cruiser Maxx Sugar Beets															●		
Cruiser Maxx Vibrance		●												●			
Cruiser Maxx Vibrance Cereals	●										●						●
Cruiser Maxx Vibrance Potato												●					

Seed Treatment	Barley	Dry Beans	Canola	Carrot	Chickpea	Corn	Field Pea	Flax	Lentil	Mustard	Oats	Potato	Safflower	Soybean	Sugarbeet	Sunflower	Wheat
Cruiser Maxx Vibrance Pulses		●			●		●		●								
Dyna-Shield Imidacloprid 5	●	●	●	●	●	●	●	●	●	●	●		●	●	●	●	●
Enhance AW	●	●			●		●		●		●			●			●
Foothold Extra	●																●
Foothold Virock	●																●
Fortenza			●			●							●	●		●	
Gaucho 600 Flowable	●	●	●	●	●	●	●	●	●	●	●		●	●	●	●	●
Helix Vibrance			●														
Helix XTra			●														
Inovate System														●			
Intego SUITE Cereals OF	●										●						●
Intego SUITE Soybeans														●			
Lorsban 50WSP		●															
Lumiderm			●							●							
ADAMA Alias 2F												●					
ADAMA Alias 4F												●					
Montana 2F												●					
Montana 4F												●					
NipsIt Inside Insecticide	●		●			●					●				●		●
NipsIt SUITE Cereals OF	●										●						●
NipsIt SUITE Sugar Beets															●		
Nuprid 2SC												●					
Nuprid 4.6F Pro												●					
Nuprid 4F Max												●					
Poncho 600			●			●											
Poncho Beta															●		
Poncho Votivo						●								●			
Prosper EverGol			●														
Rancona Crest	●										●						●
Rancona Crest WR	●										●						●
Raxil PRO Shield	●																●
Sativa IM Max	●																●
Sativa IM RTU	●																●
Senator 600FS	●	●	●	●	●	●	●	●	●	●	●		●	●	●	●	●
Upshot Soybeans														●			
Warden Cereals 360	●										●						●
Warden Cereals HR	●										●						●
Warden Cereals WR II	●										●						●
Warden CX														●			
Widow												●					
Wrangler												●					

[1] Commercial and on-farm seed treatment uses indicated in individual crop sections of this guide.

THE NEW EPA BEE ADVISORY BOX

On EPA's new and strengthened pesticide label to protect pollinators



PROTECTION OF POLLINATORS

APPLICATION RESTRICTIONS EXIST FOR THIS PRODUCT BECAUSE OF RISK TO BEES AND OTHER INSECT POLLINATORS. FOLLOW APPLICATION RESTRICTIONS FOUND IN THE DIRECTIONS FOR USE TO PROTECT POLLINATORS.

Look for the bee hazard icon in the Directions for Use for each application site for specific use restrictions and instructions to protect bees and other insect pollinators.

This product can kill bees and other insect pollinators.
Bees and other insect pollinators will forage on plants when they flower, shed pollen, or produce nectar.

Bees and other insect pollinators can be exposed to this pesticide from:

- Direct contact during foliar applications, or contact with residues on plant surfaces after foliar applications
- Ingestion of residues in nectar and pollen when the pesticide is applied as a seed treatment, soil, tree injection, as well as foliar applications.

When Using This Product Take Steps To:

- Minimize exposure of this product to bees and other insect pollinators when they are foraging on pollinator attractive plants around the application site.
- Minimize drift of this product on to beehives or to off-site pollinator attractive habitat. Drift of this product onto beehives can result in bee kills.

Information on protecting bees and other insect pollinators may be found at the Pesticide Environmental Stewardship website at:
http://pesticidestewardship.org/pollinatorprotection/Pages/default.aspx

Pesticide incidents (for example, bee kills) should immediately be reported to the state/tribal lead agency. For contact information for your state/tribe, go to: www.aapco.org. Pesticide incidents can also be reported to the National Pesticide Information Center at: www.npic.orst.edu or directly to EPA at: beekill@epa.gov

Alerts users to separate restrictions on the label. These prohibit certain pesticide use when bees are present.

The new bee icon helps signal the pesticide's potential hazard to bees.

Makes clear that pesticide products can kill bees and pollinators.

Bees are often present and foraging when plants and trees flower. EPA's new label makes it clear that pesticides cannot be applied until all petals have fallen.

Warns users that direct contact and ingestion could harm pollinators. EPA is working with beekeepers, growers, pesticide companies, and others to advance pesticide management practices.

Highlights the importance of avoiding drift. Sometimes, wind can cause pesticides to drift to new areas and can cause bee kills.

The science says that there are many causes for a decline in pollinator health, including pesticide exposure. EPA's new label will help protect pollinators.

EPA

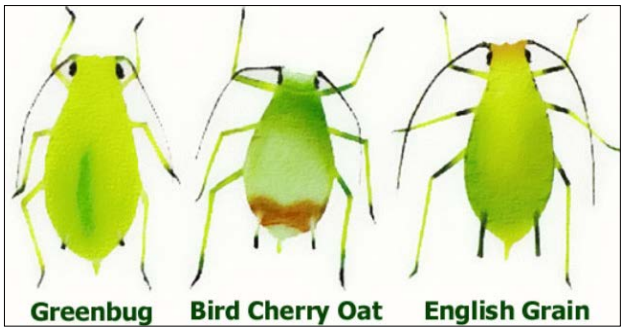
Read EPA's new and strengthened label requirements: http://go.usa.gov/jHH4

BARLEY INSECTS

Other Resources Available Through NDSU Extension Service:

Publications	E1230	North Dakota Small-Grain Insects: Cereal Leaf Beetle (2016)
	E830	The Armyworm and the Army Cutworm (revised 2018)

APHIDS



Greenbug - pale green with darker stripe down back.
Bird Cherry Oat Aphid - olive green, brownish patch at the base of cornicles.
English Grain Aphid - bright green with long black cornicles.
The greenbug, English grain aphid and bird cherry oat aphids are the principal species that cause problems in North Dakota small grains. None of these aphids are known to overwinter in North Dakota; they migrate to the region from the South in late spring. The greenbug is the most injurious because it injects a toxin with its saliva during feeding. The English grain aphid is the most common aphid seen in small grains. Its population grows rapidly when feeding on wheat heads. The bird cherry oat aphid feeds primarily on leaves in the lower part of the small grain plant. These aphids transmit barley yellow dwarf virus. When aphid populations are high, the disease can spread through small grain fields. At greatest risk are later planted fields which attract migrating aphids that are moving from more mature fields.

Thresholds: ***English Grain, Bird Cherry Oat, Greenbug***

To protect small grains from yield loss due to aphid feeding, the treatment threshold is 85% stems with more than one aphid present or 12-15 aphids per stem, prior to complete heading. Field scouting should begin at stem elongation and continue up to the heading stage of wheat. Aphid populations at or above the thresholds during these growth stages will result in economic injury to plants.

The greatest risk of yield loss from aphids feeding on grains is in the vegetative to boot stages. Significant yield reductions after the onset of flowering could not be demonstrated in research published from South Dakota in 1997 (Voss et al., 1997. J of Economic Entomology 90: 1346-1350). Reasons for these conclusions were that: after heading the only major yield component aphids can affect is seed weight; aphids are unable to sustain the very large populations necessary to achieve significant impact on this factor. Other components of yield are determined earlier (number of spikelets - determined at jointing; number of seeds - determined at flowering).

Russian Wheat Aphid (RWA):

15% to 20% of tillers infested up to flowering; 20+% infested tillers from flowering to early milk stage

Note: A tiller is infested whether it has one or several RWA present. RWA have only been found in southwest North Dakota during late summer; no economic damage has been reported. No RWA have been reported in North Dakota since the early '90s. Occasionally, RWA have overwintered during mild winters in Montana.

Natural Controls:

Lady beetles, aphid lions, syrphid fly, and parasitic wasps play a major role in reducing aphid populations. When natural enemies are present in large numbers, and the crop is well developed, farmers are discouraged from spraying fields.

ARMYWORMS

Armyworm outbreaks in North Dakota can occur when large migrations of moths from Southern states occur in late spring and early summer. Moths prefer to lay eggs in moist, shady areas where small grains or grasses have lodged or been damaged by hail or wind. Armyworms feed at night and hide under vegetation or in loose soil during the day. To scout for armyworms in grains, part the plants and inspect the soil for fecal pellets. If pellets or feeding damage is found, look for larvae under plant trash, soil clods or in soil cracks.

Threshold: Treat when 4 to 5 or more worms per square foot are present.

Migrating Armyworms: Treat a couple of swaths ahead of the infestation in the direction of movement to form a barrier strip.

BARLEY THRIPS

Female barley thrips fly to barley from overwintering sites during mid to late May. Sampling for thrips should begin when the flag leaf is first visible and continue until the head is completely emerged from the boot. Sample at least 50 feet in from field margins. Most thrips can be found under the top two leaf sheaths. The dark brown to black thrips can be found by unrolling the leaf sheaths away from the stem. Insecticide treatments are only effective when applied before heading is complete.

Threshold For Thrips: *Treat when thrips are equal to or greater than the number calculated by*

$$\textbf{Threshold (Thrips/stem)} = \frac{\textbf{Cost of Control} \div \textbf{Expected \$ value per bushel}}{0.4}$$

CEREAL LEAF BEETLE

The cereal leaf beetle is an imported insect pest from Europe. This insect has been confirmed from **Burke,Cavalier, McKenzie, Nelson, Renville, Ward and Williams counties of North Dakota**. It was first detected in Michigan in 1962, Utah in 1984, and Montana in 1989. The cereal leaf beetle is a serious pest of barley and wheat in Montana. Both adults and larvae of the cereal leaf beetle damage grain crops through their foliar feeding. The larvae are the most damaging stage and the target of control measures. Generally, the newer plant tissue is preferred with feeding occurring on the upper leaf surface causing characteristic elongated slits.

Monitoring and Treatment Threshold: The first sign of CLB activity in the spring is adult feeding damage on the plant foliage. While this is the first sign of adult activity, adults are not the target of control. Eggs and larvae are monitored by plant inspection since thresholds are expressed as egg and larvae numbers per plant or per stem. Examine 10 plants per location and select 1 location for every 10 acres of field. Count number of eggs and larvae per plant (small plants) or per stem (larger plants) and get an average number of eggs and larvae, based on the samples you have taken. Boot stage is a critical point in plant development and impact of cereal leaf beetle feeding damage can be felt on both yield and grain quality.

Before boot stage, the threshold is 3 eggs and/or larvae or more per plant (including all the tillers present before the emergence of the flag leaf). Larvae feeding in early growth stages can have a general impact on plant vigor. When the flag leaf emerges, feeding is generally restricted to the flag leaf which can significantly impact grain yield and quality.

At the boot stage - 1 larvae or more per flag leaf.

CUTWORMS

Several cutworm species affect regional crops. In western North Dakota, the pale western and the army cutworms are important pests of small grains. Eggs of pale western hatch in the spring and larvae feed underground. Eggs of the army cutworm hatch in the fall and spring feeding is above ground. In eastern North Dakota, the dingy cutworm, *Feltia jaculifera*, overwinters as a partially grown larva and is one of the first cutworm species to cause problems during crop emergence from early to mid-May. The moth of the dingy cutworm is known to lay her eggs on sunflower heads from mid-July through September. Crops following sunflowers in rotation are at greatest risk of injury by this cutworm. Other cutworms, the red-backed, *Exoa ochregaster*, and the darksided, *Exoa messoria*, overwinter as eggs which hatch in mid to late May. Eggs are laid in the fall and survive in weedy, wet, and reduced-tillage areas. Feeding injury by these cutworms normally occurs in late May to early June.

Thresholds: Treatment is recommended when cutworms number 4 to 5 per square foot.

GRASSHOPPERS

In the Northern Plains, grasshopper egg hatch normally begins in late April to early May. Peak hatch occurs about mid-June. Heavy infestations typically occur in areas of low rainfall or during drought years. Outbreaks are usually preceded by several years of hot, dry summers and warm falls. Cool, wet weather increases disease occurrence and delays development of grasshoppers, reducing the overall population.

Cultural Control Methods

Early seeding: Allows for early establishment and vigorous growth of plants.

Crop rotation: Avoid planting in areas of high egg deposits. Fields with late-maturing crops or green plant cover attract adults which then lay eggs.

Tillage: Summer fallow will act as a trap crop, attracting females for egg laying. Spring tillage of these sites will reduce successful emergence of nymphs.

Thresholds: Threatening is considered the action threshold for grasshoppers. Since it is difficult to estimate the number of grasshoppers per square yard when population densities are high, pest managers can use four 180-degree sweeps with a 15-inch sweep net, which is equivalent to the number of adult (or nymph) grasshoppers per square yard.

	Nymphs per square yard		**Adults per square yard**	
Rating	Margin	Field	Margin	Field
Light	25-35	15-25	10-20	3-7
Threatening	50-75	30-45	21-40	8-14
Severe	100-150	60-90	41-80	15-28
Very Severe	200+	120+	80+	28+

WIREWORMS

Wireworms are most likely to be problems when barley follows pasture or grassland. Infestations often are found in coarse textured soils (sandy loam) where moisture is abundant, perhaps in low spots of fields.

Thresholds: There is no easy way to estimate wireworm infestations. Two methods are currently used.

***Soil Sampling*:** Sample 20, well spaced, 1 square foot sites to a depth of 4 to 6 inches for every 40 acres being planted. If an average of 1 wireworm per square foot is found, treatment would be justified.

***Solar Baiting*:** In September, establish bait stations for 2 to 3 weeks before freeze. Place bait stations randomly through the field, but representing all areas of the field. There should be 10 - 12 stations per 40 acre field. Place one cup wheat and one cup shelled corn in a 4- to 6-inch deep hole. Cover grain with soil and then an 18-inch square piece of clear plastic. Dig up the grain. If an average of one or more wireworm larvae is found per station, treatment would be justified.

Seed Treatment: Seed treatments and/or planter box treatments are available for use on barley for managing wireworm. Please the seed treatment section in the introduction for more information.

Caution: Do not use treated seed for feed or food purposes. Prevent the contamination of commercial grain by thoroughly cleaning bins, grain augers and trucks that have been used to store, handle and/or home treat seed.

INSECTICIDES REGISTERED FOR USE IN BARLEY

INSECTICIDE	PRODUCT PER ACRE	PHI	Aphids	Armyworms	Barley Thrips	Cereal Leaf Beetle	Cutworms	Grasshoppers	Wireworms
Bacillus thuringiensis Biobit HP XenTari DF DiPel DF DiPel ES	 0.5 - 1 lb 0.5 - 2 lbs 1 - 2 lbs 2 - 4 pts	None		‡					
beta-cyfluthrin Baythroid XL *RUP*	1.8 - 2.4 fl oz	30 days for grain 3 days for grazing or forage	●	●		●	●	●	
chlorantraniliprole Prevathon	14 - 20 fl oz	14 days		●					
chlorantraniliprole + lambda-cyhalothrin Besiege *RUP*	5 - 10 fl oz	30 days	●	●		●	●	●	
clothianidin Intego SUITE Cereals OF[1] NipsIt SUITE Cereals OF[1] NipsIt Inside Insecticide[1]	5.2 fl oz per cwt 5 - 7.5 fl oz per cwt 0.25 - 1.79 fl oz per cwt	**REI:** 24 hrs	*					*	●
diflubenzuron Dimilin 2L *RUP* **FOR USE WEST OF US HIGHWAY 281 ONLY**	2 - 4 fl oz	50 days for grain or straw 15 days for hay 3 days for forage				●		●	
flupyradifurone Sivanto Prime	7 - 10.5 fl oz	7 days for forage 21 days grain, stover and straw	●						
imidacloprid Attendant 480FS Attendant 600 Dyna-Shield Imidacloprid 5 Gaucho 600 Senator 600FS	 0.16 - 0.32 fl oz per cwt 0.13 - 0.26 fl oz per cwt 0.13 - 0.26 fl oz per cwt 0.13 - 0.26 fl oz per cwt 0.13 - 0.26 fl oz per cwt	Do not graze or feed livestock on treated areas for 45 days							†
imidacloprid Attendant 480FS Attendant 600 Dyna-Shield Imidacloprid 5 Gaucho 600 Senator 600FS	 1 - 3 fl oz per cwt 0.8 - 2.4 fl oz per cwt 0.8 - 2.4 fl oz per cwt 0.8 - 2.4 fl oz per cwt 0.8 - 2.4 fl oz per cwt	Do not graze or feed livestock on treated areas for 45 days	*					*	●
imidacloprid Enhance AW	4 oz per cwt	Do not graze or feed livestock on treated areas for 45 days	*						●
imidacloprid Foothold Extra Foothold Virock Sativa IM Max	3.4 - 5 fl oz per cwt	Do not graze or feed livestock on treated areas for 45 days	*						●
imidacloprid Raxil PRO Shield Sativa IM RTU	5 fl oz per cwt	Do not graze or feed livestock on treated areas for 45 days	*						●
imidacloprid Rancona Crest Warden Cereals HR	5 - 8.33 fl oz per cwt	Do not graze or feed livestock on treated areas for 45 days	*						†
imidacloprid Rancona Crest WR Warden Cereals WR	5 - 8.33 fl oz per cwt	Do not graze or feed livestock on treated areas for 45 days							†

INSECTICIDE	PRODUCT PER ACRE	PHI	Aphids	Armyworms	Barley Thrips	Cereal Leaf Beetle	Cutworms	Grasshoppers	Wireworms
lambda-cyhalothrin Grizzly Too Kendo Lambda-Cy EC LambdaStar Lambda-T Lamcap Nufarm Lambda-Cyhalothrin 1EC Paradigm VC Province Silencer Silencer VXN Warrior II *RUP*	 0.96 - 1.92 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 0.96 - 1.92 fl oz	30 days for grain and straw 7 days for grazing and forage	●	●		●	●	●	
lambda-cyhalothrin + thiamethoxam Endigo ZC *RUP*	3.5 - 4.5 fl oz	30 days for grain, forage and straw 7 days for grazing	●	●		●	●	●	
malathion Malathion 5	1 - 2 pts	7 days	●	●		●			
malathion Malathion 57EC	1.5 - 2 pts	7 days	●	●				●	
malathion Cheminova Malathion 57%	1 - 2 pts	7 days	●			●		●	
malathion Fyfanon ULV AG	4 - 8 oz	7 days				●		●	
spinetoram Radiant SC	3 - 6 fl oz	21 days for grain and straw harvest 3 days for forage, fodder or hay harvest		●		●			
spinosad Blackhawk Entrust Spintor 2SC Tracer	1.1 - 3.3 oz 1 - 2 oz 2 - 6 fl oz 1 - 3 fl oz	21 days for for grain and straw harvest 3 days for forage, fodder and hay		●		●		†	
sulfoxaflor Transform WG	0.75 - 1.5 oz	14 days for grain and straw 7 days for forage, fodder and hay harvest	●						
thiamethoxam Actara	4 oz	21 days	●						
thiamethoxam Cruiser 5FS	0.75 - 1.33 fl oz per cwt	Do not graze or feed livestock on treated areas for 45 days	*						●
thiamethoxam Cruiser Maxx Cereals[2] Cruiser Maxx Vibrance Cereals	5 fl oz per cwt 5 - 10 fl oz per cwt	Do not graze or feed livestock on treated areas for 45 days	*						●
thiamethoxam Warden Cereals 360[3] Warden Cereals WR II[3]	5 fl oz per cwt	Warden Cereals WR II: Do not graze or feed livestock on treated areas for 45 days	*						●

RUP = Restricted Use Pesticide
● = Control
* = Seed treatments may not give control of grain aphids or grasshoppers
† = Suppression only
‡ = Control of first and second instar larvae only when populations are light

[1] = For protection against early season aphids, grasshoppers or heavy wireworms pressure, add 1.4 to 1.5 fl oz per cwt of NipsIt INSIDE Insecticide to NipsIt SUITE Cereals OF or Intego SUITE Cereals OF; consult each label for registered use rates and follow all label instructions.
[2] = For protection against early season aphids, Cruiser Maxx Cereals must be mixed with 0.48 - 1 fl oz per cwt of Cruiser 5FS; consult each label for registered use rates and follow all label instructions.
[3] = For aphid and wireworm control, add up to 0.8 fl oz per cwt of Cruiser 5FS.

BEAN (DRY EDIBLE) INSECTS

Other resources available through NDSU Extension Service:

Publications	A1133	Dry Bean Production Guide (2019)
	E1884	2017 Dry Bean Grower Survey of Pest Problems and Pesticide Use in MN and ND (2018)
	E830	The Armyworm and the Army Cutworm (revised 2018)

APHIDS

Aphid Management

The bean aphid has not been a major pest in North Dakota, though it can be found. It is nearly black in color and 1/8 inch long. They feed along stems and the underside of leaves. Infestations may result in a buildup of honeydew on leaf surfaces, promoting the growth of a black "sooty" fungus. No economic threshold guidelines for control have been established for North Dakota.

ARMYWORMS

Armyworms are more of a problem in small grains and corn. Damage to dry beans can occur when their usual host plants become depleted. They are inactive during the day, resting under plant trash, and clumps of grass or lodged plants. They feed at night by crawling up on plants and consuming foliage.

Threshold: Control of armyworms is recommended when 25% to 30% of the foliage is destroyed or if significant injury to pods is evident.

BEAN LEAF BEETLE

This beetle can vary in color from yellow to reddish-brown, and may have three to four black spots and a black border on the wing covers. Adults emerge from overwintering, moving into bean fields as the seedlings emerge. The white larvae develop in the soil, feeding on the roots and nodules. New adults emerging in July feed on foliage and pods. The injury to pods results in secondary infections by fungi and bacteria, causing rotting and discoloration.

Threshold: Due to low incidence of this insect in North Dakota, no local control guidelines have been developed. University of Missouri entomologists suggest treatment when 40% to 70% of the bean plants show feeding injury on one or more of the pods/plant.

CUTWORMS

Most damage by cutworms occurs when bean plants are in the early stage of development. Damage consists of young plants being chewed off slightly below or at ground level. Some cutworm feeding injury may occur on foliage. Cutworms primarily feed at night. When checking bean fields for cutworms during the day, dig down into soil an inch or two around recently damaged plants; there you can find the gray to gray-brown larva.

Threshold: Treatment is warranted when one cutworm or more is found per 3 feet of row and the larvae are small (<3/4 inch long).

FOLIAGE FEEDING CATERPILLARS

Green Cloverworm, Cabbage Looper, Velvetbean Caterpillar, Thistle Caterpillar, and Alfalfa webworm

Populations of these caterpillars have been negligible in North Dakota and little treatment to control them has been required. The exception was the 2001 growing season when many of these caterpillars affected bean fields. Sampling for these insects is accomplished through the use of a drop cloth or a vertical beat sheet, placed between two rows of plants. The larvae are dislodged from the plants and counted on the cloth or collection tray to arrive at an estimate of the number per row feet.

Green cloverworm: These caterpillars are green with two narrow, white stripes down the side. When mature, the worms are 1 ¼ inches long. These caterpillars have only three pairs of fleshy prolegs on the abdomen, plus the pair on the back tip. When moving, the worms move by arching the middle of the body, or “looping.” Young worms scrape leaf tissue, creating a transparent skin, or "window," on the leaf surface. Older clover worms eat holes in the leaves.

Cabbage looper: These caterpillars are light to dark green with lighter colored stripes, along the side and on the top, running the length of the body. When mature, the worms are 1 ½ inches long. These caterpillars have only two pairs of fleshy prolegs on the abdomen, plus the pair on the back tip. When moving, the caterpillars move by arching the middle of the body, or “looping.” These worms feed on leaves on the interior and lower portion of the plant. As defoliation occurs, worms feed higher in the plant. Feeding injury is similar to the cloverworm.

Velvetbean caterpillar: This insect does not overwinter in the region, instead, moths migrate from Southern locations. These caterpillars have dark lines bordered by lighter colored, narrower lines running the length of the body. The background color ranges from a pale yellow-green to brown or black. These larvae have four pairs of fleshy prolegs to distinguish them from the cloverworm and the looper. Young velvetbean caterpillars feed on the underside of leaves in the upper portion of the plant. Older larvae consume the entire leaf, except for the leaf veins.

Thistle caterpillar: This insect is the larva of the butterfly known as the Painted Lady. This butterfly does not overwinter in the region, but migrates from Southern locations each spring. These caterpillars are brown to black in color with yellow stripes along each side of the body. They are covered with spiny-hairs that give the caterpillar a prickly appearance. Full grown larvae are about 1 ½ inches long. The caterpillars feed on the leaves, webbing them together at the feeding site.

Alfalfa webworm: These larvae are 1 inch when full grown. They are greenish to nearly black with a light stripe that runs down the middle of the back. There are three dark spots, each with hairs, on the side of each segment. These larvae feed for about 3+ weeks. Infestations are characterized by light webbing over the leaves. These larvae move very rapidly, forward or backward, when disturbed.

Threshold for foliage feeding caterpillars: Control of these different caterpillars is normally not warranted until greater than 30% of the foliage is destroyed. This usually requires an average infestation of 10 to 15 larvae per row foot.

GRASSHOPPERS

In the Northern Plains, grasshopper egg hatch normally begins in late April to early May. Most grasshoppers emerge from eggs deposited in uncultivated ground. Bean growers should expect to find grasshoppers feeding first along bean field margins adjacent to these sites. Later infestations may develop when grasshopper adults migrate from harvested small grain fields. Grasshoppers will attack leaves and pods, creating holes. Due to these migrations, bean fields become sites for significant egg laying.

Thresholds: Threatening is considered the action threshold for grasshoppers. Since it is difficult to estimate the number of grasshoppers per square yard when population densities are high, pest managers can use four 180-degree sweeps with a 15-inch sweep net, which is equivalent to the number of adult (or nymph) grasshoppers per square yard.

	Nymphs per square yard		**Adults per square yard**	
Rating	Margin	Field	Margin	Field
Light	25-35	15-25	10-20	3-7
Threatening	50-75	30-45	21-40	8-14
Severe	100-150	60-90	41-80	15-28
Very Severe	200+	120+	80+	28+

LEAFHOPPERS

Leafhopper Management

The adult is wedge-shaped and pale green in color. Adults are very active, jumping or flying when disturbed. Nymphs are wingless. Both adults and nymphs will run backwards or sideways rapidly. Large numbers of adults may appear early in the season. Nymphs usually complete their growth on the leaf where they hatched, feeding on the underside of the leaf. Damage by leafhoppers is referred to as 'hopperburn.' Foliage becomes dwarfed, crinkled, and curled. Small triangular brown areas appear at the tips of leaves, gradually spreading around the entire leaf margin. Both nymphs (immatures) and adults cause damage and should be counted when field scouting.

Threshold: The threshold for basing spray decisions is an **average of 0.5 leafhopper per plant in the unifoliate stage and one leafhopper per trifoliate leaf for later stages**. Do not let infestations and damage progress to the point that yellowing of foliage is easily detected, because damage and yield loss has already occurred. Immediate treatment reduces further damage and protects new growth.

SEEDCORN MAGGOT

Seed corn maggot attack bean seed, preventing sprouting or weakening seedlings. The yellowish white maggot is found burrowing in the seed or emerging stem. The adult flies emerge in spring when soil temperatures reach 50º F. They deposit eggs in soil where there is abundant organic matter and decaying crop residue, or on the seed or seedling. Seed corn maggots are usually most severe in wet, cold seasons and on high organic matter soils.

Threshold: When conditions are wet and cool or planting into high crop residue conditions, seed treatments will provide the best defense against injury. Please see the seed treatment section in the introduction for more information.

SPIDER MITES

Mites are small and magnification is required to see them. A quick sampling procedure to determine whether mites are present is to hold a piece of white paper below leaves then slap them to dislodge the mites. Or, pulling plants and examining the underside of the leaves from the bottom of plants upwards. The mites appear as tiny dust specks; however, they will move after being knocked off the leaf. Feeding damage by mites first appears as small yellow spots ("stippling"). As feeding activity increases, leaves become yellow, bronzed or brown, and eventually shed from the plant. Mite webbing may be present on plants as mites balloon on webs to disperse within and between fields.

Mites usually become a problem when hot, dry weather occurs. Infestations typically are first noted near field edges. These environmental conditions stress the plant, whether mites are present or not. If conditions continue, treating for mites is no guarantee plants will recover. In addition, products labeled for mite control often do not give adequate control and the population of mites may rebound quickly to pretreatment levels or higher. When rain and humidity are present, natural reductions in mite populations occur due to infection by a fungal pathogen. Conditions that are good for the development of the pathogen are temperatures cooler than 85º F, with at least 90% R.H. for 12 to 24 hours.

Threshold: Deciding whether to treat is difficult. There is no specific threshold that has been developed for two-spotted spider mite in dry edible beans. Sample plants at least 100 feet into the field and walk in a "U" pattern sampling two plants per location at 20 different locations. A general action threshold is to treat when the lower ¼ to ⅓ of canopy has mite damage symptoms and/or mites present. (Source: University of Minnesota, Ostlie & Potter).

Remember to use an organophosphate insecticide (e.g. Dimethoate) over a pyrethroid insecticide to avoid flaring mite populations. However, the active ingredient bifenthrin (a pyrethroid) does not flare mite populations. Reasons for the increase in mite populations from some pyethroids include: disruption of the natural enemies that control spider mites (predatory mites); increased movement of mites out of fields, and increased reproductive rates of female mites. Early detection facilitates timely and effective rescue treatments. Insecticides provide short-term protection, maybe 7 days, from the spider mites. Fields will need to be re-monitored continually for resurging populations. The efficacy of an insecticide can be improved significantly with sufficient water coverage (>18 GPA) by ground and 3-5 GPA by air and application at high pressure to penetrate foliage. For insecticide resistance management of mites, do not apply the same class of insecticide (or mode of action) more than twice and alternate the class of the insecticides (or mode of action) to prevent buildup of resistant mite strains.

WIREWORMS

Wireworms are most likely to be problems when dry beans follow pasture or grassland. Infestations often are found in coarse textured soils (sandy loam) where moisture is abundant, perhaps in low spots of fields.

Thresholds: There is no easy way to estimate wireworm infestations. Two methods are currently used.

***Soil Sampling*:** Sample 20, well spaced, 1 square foot sites to a depth of 4 to 6 inches for every 40 acres being planted. If an average of 1 wireworm per square foot is found, treatment would be justified.

***Solar Baiting*:** In September, establish bait stations for 2 to 3 weeks before freeze. Place bait stations randomly through the field, but representing all areas of the field. There should be 10 - 12 stations per 40 acre field. Place one cup wheat and one cup shelled corn in a 4- to 6-inch deep hole. Cover grain with soil and then an 18-inch square piece of clear plastic. Dig up the grain. If an average of one or more wireworm larvae is found per station, treatment would be justified.

***Seed Treatment*:** Please the seed treatment section in the introduction for more information.

INSECTICIDES REGISTERED FOR USE IN DRY EDIBLE BEANS

INSECTICIDE	PRODUCT PER ACRE	PHI	Aphids	Armyworms	Bean Leaf Beetle	Caterpillars	Cutworms	Grasshoppers	Leafhoppers	Seed Corn Maggot	Spider Mites	Wireworms
abamectin Agri-Mek 0.15EC *RUP*	8 – 16 fl oz	7 days									●	
abamectin Agri-Mek SC *RUP*	1.75 - 3.5 fl oz	7 days									●	
acephate Acephate 75WSP Acephate 90 Prill Acephate 90 WDG Acephate 97 Acephate 97UP	 0.33 - 1.33 lb 4.4 oz - 1.1 lb 4.4 oz - 1.1 lb 0.25 - 1 lb 0.25 - 1 lb	14 days Do not feed treated vines or hay	●	●	●	●	●	●	●			
alpha-cypermethrin Fastac CS *RUP*	**At-plant:** 3.8 fl oz	21 days					●					●
alpha-cypermethrin Fastac CS Fastac EC *RUP*	**Foliar:** 1.3 - 3.8 fl oz	21 days	†	●	●	●	●	●	●			
Bacillus thuringiensis* ssp. *kurstaki Biobit HP XenTari DF DiPel DF DiPel ES	 0.5 - 2 lbs 0.5 - 2 lbs 1 - 2 lbs 1 - 4 pts	None.		‡		●						
beta-cyfluthrin Baythroid XL *RUP*	0.8 - 3.2 fl oz	7 days Do not feed treated vines or hay	†	‡	●	●	●	●	●			

INSECTICIDE	PRODUCT PER ACRE	PHI	Aphids	Armyworms	Bean Leaf Beetle	Caterpillars	Cutworms	Grasshoppers	Leafhoppers	Seed Corn Maggot	Spider Mites	Wireworms
beta-cyfluthrin + imidacloprid Leverage 360 *RUP*	2.4 - 2.8 fl oz	7 days Do not feed treated vines or hay	●	‡	●	●	●	●	●			
bifenazate Acramite 4SC	16 - 24 fl oz	7 days									●	
bifenthrin Bifen 2 AG Gold Bifenture EC Brigade 2EC Fanfare 2EC Sniper Sniper Helios Tundra EC *RUP*	1.6 - 6.4 fl oz 1.6 - 6.4 fl oz 1.6 - 6.4 fl oz 1.6 - 6.4 fl oz 1.6 - 6.4 fl oz 1.6 - 6.4 fl oz	14 days	●	●	●	●	●	●	●		●	
bifenthrin Bifender FC *RUP*	Broadcast to soil (armyworm and cutworm): 2.9 – 5.9 fl oz At-plant: 0.17 - 0.34 fl oz per 1000 linear feet	None listed		●			●			●		●
bifenthrin Capture LFR Sniper LFR *RUP*	Broadcast to soil (armyworm and cutworm): 3.4 - 6.8 fl oz At-plant: 0.2 - 0.39 fl oz per 1000 linear feet	None listed		●			●			●		●
bifenthrin Ethos XB *RUP*	Broadcast to soil (armyworm and cutworm): 3.4 - 8.5 fl oz At-plant: 0.2 - 0.49 fl oz per 1000 linear feet	None listed		●			●			●		●
bifenthrin + imidacloprid Brigadier Skyraider Swagger *RUP*	3.8 - 5.6 fl oz 2.1 - 5.6 fl oz 7.6 - 11.2 fl oz	14 days	●	●	●	●	●	●	●		●	
bifenthrin + zeta-cypermethrin Hero *RUP*	4.0 - 10.3 fl oz	21 days	●	●	●	●	●	●	●		●	
carbaryl Sevin 4F Sevin XLR Plus	0.5 - 1.5 qts 0.5 - 1.5 qts	21 days		●	●	●	●	●	●			
chlorantraniliprole Coragen	3.5 - 5 fl oz	1 day		●								
chlorantraniliprole + lambda-cyhalothrin Besiege *RUP*	5 - 10 fl oz	21 days	●	●	●	●	●	●	●			
chlorpyrifos Lorsban 50WSP *RUP*	**COMMERCIAL SEED TREATMENT ONLY**	None								●		

INSECTICIDE	PRODUCT PER ACRE	PHI	Aphids	Armyworms	Bean Leaf Beetle	Caterpillars	Cutworms	Grasshoppers	Leafhoppers	Seed Corn Maggot	Spider Mites	Wireworms
chlorpyrifos Chlorpyrifos 4E AG Govern 4E Hatchet Lorsban 4E Lorsban Advanced Nufos 4E Vulcan Warhawk Yuma 4E *RUP*	Preplant broadcast: 2 pt At-plant T-band: 1.8 fl oz per 1000 linear feet at 30" row spacing	None								●		
chlorpyrifos + bifenthrin Match-Up *RUP*	2.05 - 16.4 fl oz	14 days	●	●	●	●	●	●	●		●	
cyantraniliprole Exirel	10 - 20.5 fl oz	7 days		●		●	●		*			
cyantraniliprole + abamectin Minecto Pro *RUP*	7.5 - 10 fl oz	7 days							*		●	
cyfluthrin Tombstone Tombstone Helios *RUP*	0.8 - 3.2 fl oz 0.8 - 3.2 fl oz	7 days Do not feed treated vines or hay	†	‡	●	●	●	●	●			
dimethoate Dimate 4E Dimethoate 400 Dimethoate 4E Dimethoate 4EC	0.5 - 1 pt 0.5 - 1 pt 0.5 - 1 pt 0.5 - 1 pt	No PHI Do not feed vines	●		●			●	●		●	
esfenvalerate Asana XL *RUP*	5.8 - 9.6 fl oz	21 days Do not feed or graze treated vines	●			●	●	●	●			
flupyradifurone Sivanto Prime	7 - 10.5 fl oz	7 days	●						●			
gamma-cyhalothrin Declare *RUP*	1.02 - 1.54 fl oz	21 days Do not graze or feed treated vines	●	●	●	●	●	●	●			
imidacloprid Attendant 480FS Attendant 600 Dyna-Shield Imidacloprid 5 Gaucho 600 Senator 600FS	**COMMERCIAL SEED TREATMENT ONLY** 2 - 4 fl oz per cwt 1.6 - 3.2 fl oz per cwt 1.6 - 3.2 fl oz per cwt 1.6 - 3.2 fl oz per cwt 1.6 - 3.2 fl oz per cwt	None	●		●				●			●
imidacloprid Enhance AW	5 oz per cwt	Do not graze or feed livestock on treated area for 60 days after planting	●		●				●			●
imidacloprid Pasada 1.6F Prey 1.6F Sherpa	Foliar application: 3.5 fl oz	7 days	●						●			
imidacloprid ADAMA Alias 2F AmTide Imidacloprid 2F Malice 2F Montana 2F Nuprid 2SC Widow	Soil applications: 16.0 - 24.0 fl oz	21 days	●						●			

INSECTICIDE	PRODUCT PER ACRE	PHI	Aphids	Armyworms	Bean Leaf Beetle	Caterpillars	Cutworms	Grasshoppers	Leafhoppers	Seed Corn Maggot	Spider Mites	Wireworms
imidacloprid AmTide Imidacloprid 2F Nuprid 2SC	Foliar application: 2.8 fl oz	7 days	●						●			
imidacloprid ADAMA Alias 4F Advise Four Montana 4F Nuprid 4F Max Wrangler	Soil applications: 8.0 - 12.0 fl oz	21 days	●						●			
imidacloprid ADAMA Alias 4F Advise Four Montana 4F Nuprid 4F Max	Foliar application: 1.4 fl oz	7 days	●						●			
imidacloprid Admire Pro Nuprid 4.6F Pro	Soil applications: 7.0 - 10.5 fl oz	21 days	●						●			
imidacloprid Admire Pro	Foliar application: 1.2 fl oz	7 days	●						●			
imidacloprid Malice 75WSP	0.9 oz	7 days	●						●			
lambda-cyhalothrin Grizzly Too Kendo Lambda-Cy EC LambdaStar Lambda-T Lamcap Nufarm Lambda-Cyhalothrin 1EC Paradigm VC Province Silencer Silencer VXN Warrior II *RUP*	0.96 - 1.92 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 0.96 - 1.92 fl oz	21 days Do not graze or harvest vines for forage or hay	●	●	●	●	●	●	●			
malathion Fyfanon ULV AG	8 fl oz	1 day Do not graze or feed vines, straw or hay	●			●			●			
methomyl Lannate LV *RUP*	0.75 - 3 pts	14 days	●	●			●		●			
methoxyfenozide Intrepid 2F	4 - 8 fl oz (early season) 8 - 16 fl oz (late season)	7 days		●								
naled Dibrom 8 Emulsive *RUP*	1 - 1.5 pts	1 day	●			●			●		●	
novaluron Rimon 0.83EC	6 - 12 fl oz	1 day		‡	‡	‡						
phorate Thimet 20G SmartBox Thimet 20G Lock n Load *RUP*	4.5 - 7.0 oz/1,000 ft of row - minimum 30-inch spacing **Do not allow granules to contact seed**	60 days	●						●	●		
spinosad Blackhawk Entrust Spintor 2SC	2.2 - 3.3 oz 1.25 - 2 oz 4 - 6 fl oz	28 days Do not feed forage or hay		●		●						

INSECTICIDE	PRODUCT PER ACRE	PHI	Aphids	Armyworms	Bean Leaf Beetle	Caterpillars	Cutworms	Grasshoppers	Leafhoppers	Seed Corn Maggot	Spider Mites	Wireworms
spinetoram Radiant SC	4 - 8 fl oz	28 days		●		●						
spirotetramat Movento Movento HL	4 - 5 fl oz 2 - 2.5 fl oz	7 days	●									§
sulfoxaflor Transform WG	0.75 - 1 oz	7 days	●									
thiamethoxam Cruiser 5FS Cruiser Maxx Cruiser Maxx Vibrance Cruiser Maxx Vibrance Pulses	1.28 fl oz per cwt 3 fl oz per cwt 3.22 fl oz per cwt 5 fl oz per cwt	None	●		●				●	●		●
zeta-cypermethrin Mustang Maxx *RUP*	At plant T-band or in-furrow application: 4 fl oz	None					●					●
zeta-cypermethrin Mustang Maxx *RUP*	1.28 - 4 fl oz	21 days	●	●	●	●	●	●	●			

RUP = Restricted Use Pesticide
● = Control
† = Pea aphid suppression only
‡ = Control of early instar larvae only
§= Wireworm suppression only
* = Leafhopper suppression only

CANOLA INSECTS

Other Resources Available Through NDSU Extension Service:

Publications	A1280	Canola Production Field Guide (2019)
	A686	Canola Production (2015)
	E1346	Diamondback Moth in Canola: Biology and Integrated Pest Management (2016)
	E1347	Bertha Armyworm in Canola: Biology and Integrated Pest Management (2016)
	E1234	Integrated Pest Management of Flea Beetles in Canola (2017)
	E830	The Armyworm and the Army Cutworm (revised 2018)

APHIDS

Several species of aphids (cabbage aphid, turnip aphid, green peach aphid) infest canola and other plants in the Mustard family. Individual aphids are small, approximately 2 mm in length, with a pair of tube-like structures called cornicles protruding from the back. Aphids on canola are usually pale green to grayish green and found in large numbers near the top of individual plants. Infested plants often appear shiny from the honeydew they secrete. Most aphids migrate into North Dakota from the southern states, and some may overwinter here. Aphids arrive in canola during the late spring; as a result later planted canola may be more susceptible to heavy aphid infestations. Females reproduce asexually and within 7 days give birth to live young. As aphid populations build up and become crowded, winged adults are produced which disperse to begin new colonies. There are multiple, overlapping generations of aphids within a season. Aphids suck on the plant's sap and inhibit terminal growth stunting plant size and reducing seed yield. Aphid infestations are often localized within a field, and usually cause little damage if the infestations occur after pod development.

Threshold: There are no established thresholds for aphids on canola. In most cases, spraying is not economical, because aphids are located on the top 2-3 inch of the plant where pods are the smallest and contribute little to the overall yield. However, controls may be justified when at least 20% of the stems are infested with a cluster of aphids in late flowering or early pod stages. Scout field edges in upwind areas where aphids tend to be abundant. Note the presence of natural enemies as well as aphids. A treatment may be necessary if the following conditions are met: 1) canola was planted late; 2) plants are still in pod development; and 3) natural enemies like ladybird beetle adults and larvae, syrphid fly larvae, or lacewing larvae are low. Follow safe pesticides practices when spraying flowering canola to protect honey bees.

ASTER LEAFHOPPER

The aster leafhopper, *Macrosteles quadrilineatus*, overwinters as eggs and migrates into North Dakota. This insect feeds by sucking juices from the canola plants, but its feeding injury does not damge the plant. More importantly, aster leafhoppers vector the Aster Yellows phytoplasm, and infect canola plants while feeding. The damage from these insects is most serious on late-seeded crops. Damage symptoms include red or purple tinge to plants, bladdering of pods, taller plants than the rest of the canopy, and misshapen seeds. Aster leafhoppers can be monitored using sweep nets or sticky traps to give producers an early warning of potentially high populations. No economic threshold has been established for canola.

BERTHA ARMYWORM

The Bertha armyworm attacks many kinds of broadleaf plants, including canola, flax and beans. Areas of North Dakota where this insect may be found include the north-central counties of Bottineau, Rollette, Towner, and neighboring areas. The larvae are pale green when they first hatch. These larvae feed on the leaves. Older larvae reach a length of 3/4 to 1 inch and will be velvety brown to black with a yellowish band along each side of the body. As leaves dry, these larvae begin feeding on seeds and flowers which are more succulent. The greatest risk of crop injury occurs in August as the worms approach full growth. In Canada, where this insect is a more frequent pest, early seeded canola often has been swathed prior to the occurrence of significant feeding injury.

Threshold: Thresholds would be 18 to 22 larvae per square yard, as long as leaf feeding is the extent of the damage observed. Thresholds may be adjusted lower if larvae are found feeding on maturing seed pods.

BLISTER BEETLES

Several species of blister beetle feed on canola including: *Lytta nuttalli*, a large purplish green beetle; *Epicauta fabricii* or the Ash-gray blister beetle; and *Epicauta ferruginea,* a smaller rusty color, pubescent beetle. Most species of blister beetle have one generation a year. Adults become active in early to mid summer and lay eggs in the soil. Eggs hatch in about two weeks into a larvae called triungulins, which actively prey on grasshopper egg pods (genus *Epicauta*) and bee eggs, larvae, and stored food (genus *Lytta*). Larvae overwinter. Adult blister beetles are attracted to blooming canola fields, where they are ravenous feeders devouring leaves, stems, flowers, and pods. These beetles are mobile and often congregate in certain spots in a field from their gregarious behavior. In some instances, blister beetles feed for a short period of time and then migrate to other plants or fields.

Threshold: The presence of large numbers of blister beetles in spots of a canola field has often concerned growers. However, adult feeding is generally not significant enough to warrant an insecticide treatment. The "High Plains Integrated Pest Management Guide" recommends treatment when there are 10 adult blister beetles per plant feeding on the flowers or pods. However, there is no economic threshold developed for North Dakota. Spot treatment with foliar insecticides registered in North Dakota is usually recommended when necessary. These insecticides will control blister beetles. Follow safe pesticides practices when spraying flowering canola to protect honey bees.

CUTWORMS

Most damage by cutworms occurs during seedling stage. Army cutworm feeding as early as late April has caused problems in recent years for canola growers in southwestern North Dakota. Cutworm damage consists of young plants being chewed off slightly below or at ground level. Some cutworm feeding injury may occur on foliage. Cutworms primarily feed at night. When checking canola fields for cutworms during the day, dig down into soil an inch or two around recently damaged plants; there you can find the gray to gray-brown larva.

Threshold: Treatment is warranted when one cutworm or more is found per 3 feet of row and the larvae are small (<3/4 inch long).

DIAMONDBACK MOTH

Diamondback moths move to canola, rapeseed and other mustard hosts in late spring and early summer. The first eggs are laid on the lower leaves. The small, greenish larvae make tiny, irregular holes in the leaves. Moths of later generations lay eggs higher on the plant. These hatching larvae feed first on leaves, moving later to buds, flowers and developing seedpods. Foliar damage by diamondback moth larvae looks bad, but significant yield losses are not common. Damage would be much worse when plants are under drought or heat stress.

Threshold: Treat when larval counts reach 25 to 30 per square foot, or 1 to 2 larvae per plant, and there is significant evidence of damage to flowers and/or pods.

FLEA BEETLES

Flea beetles are the most serious pest of canola in North Dakota. The adult beetles feed on the emerging cotyledon and first true leaves of the young plant. Feeding injury can result in plant death and significant stand loss, especially during hot, dry weather. Flea beetles overwinter as adults. They become active when temperatures reach 58º F. The beetles fly to canola, rapeseed and other mustards, moving into fields just as the seedlings emerge. The feeding injury appears as holes or small pits in the cotyledons and leaves. Injury can range from a few shot holes to destruction of the entire plant. Flea beetles feed most actively when the weather is sunny, warm and dry. Beetle activity is less when weather conditions are cool and damp. When warm, dry conditions exist and feeding injury is occurring, the plant can be stressed quickly. Cool, damp conditions can reduce the feeding intensity of the beetles and aid plant growth to the point where they can withstand the feeding damage. Once the crop is beyond the seedling stage and the first true leaves are fully expanded, serious damage usually does not occur. By mid-June, adult beetles decrease in number.

Flea Beetle Management

***Early Planting*:** The early planting and establishment of canola can prevent significant injury to young plants by flea beetles migrating to fields after the first true leaves are fully expanded.

***Seed Treatment*:** Helix®, NipsIt INSIDE® and Poncho® are for use by commercial seed treaters.

***Foliar Treatment*:** Fields should be checked daily for the presence of flea beetles while canola plants are at risk. The treatment threshold is when injury is approaching 25% and beetles are present. Foliar treatments must be made quickly. The weakness of foliar control strategies is the inability to cover large number of acres quickly when feeding pressure is high, and residual protection by the insecticides is short, allowing for reinfestation to occur.

GRASSHOPPERS

Thresholds: Grasshopper control is advised whenever 20 or more adults per square yard are found in field margins or 8 to 14 adults per square yard are occurring in the crop. In the table, threatening is considered the action threshold for grasshoppers. Since it is difficult to estimate the number of grasshoppers per square yard when population densities are high, pest managers can use four 180-degree sweeps with a 15-inch sweep net, which is equivalent to the number of adult (or nymph) grasshoppers per square yard.

	Nymphs per square yard		Adults per square yard	
Rating	Margin	Field	Margin	Field
Light	25-35	15-25	10-20	3-7
Threatening	50-75	30-45	21-40	8-14
Severe	100-150	60-90	41-80	15-28
Very Severe	200+	120+	80+	28+

LYGUS BUGS (TARNISHED PLANT BUGS)

Lygus bugs are comprised of several species belonging to the genus *Lygus*. The tarnished plant bug, *Lygus lineolaris*, is one of the more common species and is known to feed on over 200 host plants. Adult Lygus bugs are about ¼ inch in length, and pale green, light brown, or dark brown with a distinctive triangular marking on its back. Lygus bugs overwinter as adults in weedy areas and move into canola fields throughout the season. Adults lay eggs in the stems, leaves, and flowers of host plants, and then die. Immature nymphs hatch from these eggs. These nymphs are small, green, and sometimes confused with aphids; although Lygus nymphs are very active and move rapidly when disturbed, while aphids do not. Several generations occur each year with the second generation occurring in late July to early August. Hot dry weather favors the buildup of Lygus populations and increases the risk of damage to the canola crop. Both immature and adult Lygus bugs feed on growing points, buds, flowers, and green pods. Lygus bugs inject a toxic saliva with their

piercing sucking mouthparts during feeding, causing blasting of flowers or buds and shriveled seeds. Blasted flowers turn white within 24 hours and quickly fall to the ground. The small seeds or damaged seeds are lost during harvest.

Lygus Bug Thresholds: Scout for Lygus bugs from just prior to bud formation until seeds within the pod have become firm. Lygus populations can increase suddenly. For example, when an alfalfa (preferred host) is cut, Lygus will migrate quickly into nearby canola fields and often in high numbers. Use a 15-inch sweep net and make 10 180-degree sweeps at several sampling sites. The economic thresholds developed in Canada are: 15 Lygus bugs per 10 sweeps from bud stage through petal drop, and 20 Lygus bugs per 10 sweeps after petal drop. If soil moisture is good, canola plants usually can compensate for Lygus bug feeding injury to plants in the bud and flowering stages. However, if populations are high, control during the early pod ripening stage is usually the most economical.

WIREWORMS

Wireworms are most likely to be problems when canola follows pasture or grassland. Infestations often are found in coarse textured soils (sandy loam) where moisture is abundant, perhaps in low spots of fields.

Thresholds: There is no easy way to estimate wireworm infestations. Two methods are currently used.

***Soil Sampling*:** Sample 20, well spaced, 1 square foot sites to a depth of 4 to 6 inches for every 40 acres being planted. If an average of 1 wireworm per square foot is found, treatment would be justified.

***Solar Baiting*:** In September, establish bait stations for 2 to 3 weeks before freeze. Place bait stations randomly through the field, but representing all areas of the field. There should be 10 - 12 stations per 40 acre field. Place one cup wheat and one cup shelled corn in a 4- to 6-inch deep hole. Cover grain with soil and then an 18-inch square piece of clear plastic. Dig up the grain. If an average of one or more wireworm larvae is found per station, treatment would be justified.

***Seed Treatment*:** Please the seed treatment section in the introduction for more information.

INSECTICIDES REGISTERED FOR USE IN CANOLA

INSECTICIDE	PRODUCT PER ACRE	PHI	Aphids	Aster Leafhopper	Bertha Armyworm	Blister beetles	Cutworms	Diamondback Moth	Flea Beetles	Grasshoppers	Lygus Bugs	Wireworm
Bacillus thuringiensis												
DiPel DF	0.5 - 2 lbs	None			†							
XenTari DF												
bifenthrin												
Bifender FC	2.4 - 2.9 fl oz	35 days										
Bifenthrin 10DF	5.3 - 6.4 oz											
Bifen 2 AG Gold	2.1 - 2.6 fl oz											
Bifenthrin 2EC	2.1 - 2.6 fl oz											
Bifenture EC	2.1 - 2.6 fl oz											
Brigade 2EC	2.1 - 2.6 fl oz		●	*	●	*	●	●	●	●	●	
Discipline 2EC	2.1 - 2.6 fl oz											
Fanfare 2EC	2.1 - 2.6 fl oz											
Sniper	2.1 - 2.6 fl oz											
Sniper Helios	2.1 - 2.6 fl oz											
Tundra EC *RUP*	2.1 - 2.6 fl oz											
chlorantraniliprole												
Coragen	3.5 - 5 fl oz	21 days						●				
Prevathon	14 - 20 fl oz											
chlorantraniliprole + lambda-cyhalothrin												
Besiege *RUP*	5 - 10 fl oz	21 days		*	●	*	●	●	●	●	●	
clothianidin												
NipsIt INSIDE Insecticide	**COMMERCIAL SEED TREATMENT ONLY** 10.23 fl oz per cwt	Do not graze or feed livestock							●			●
clothianidin												
Prosper EverGol	**COMMERCIAL SEED TREATMENT ONLY** 21.5 fl oz per cwt	None indicated							●			●
cyantraniliprole												
Exirel	7 - 17 fl oz	7 days			●		●	●	●			

INSECTICIDE	PRODUCT PER ACRE	PHI	Aphids	Aster Leafhopper	Bertha Armyworm	Blister beetles	Cutworms	Diamondback Moth	Flea Beetles	Grasshoppers	Lygus Bugs	Wireworm
cyantraniliprole Fortenza	**COMMERCIAL SEED TREATMENT ONLY** 7.7 or 20.4 fl oz per cwt Use high rate for flea beetles	None. Consult label for rotational crop restrictions.					●		●			●
cyantraniliprole Lumiderm	**COMMERCIAL SEED TREATMENT ONLY** 3.7 - 24.6 fl oz per cwt Use high rate for flea beetles	None. Consult label for rotational crop restrictions.					●		●			
deltamethrin Delta Gold *RUP*	0.8 fl oz	7 days		*	●		●	●	●	●	●	
gamma-cyhalothrin Declare *RUP*	0.77 - 1.54	7 days	●	*	●	*	●	●	●	●	●	
imidacloprid Attendant 480FS Dyna-Shield Imidacloprid 5 Gaucho 600 Senator 600 FS	12.8 - 32 fl oz per cwt 10.24 - 25.6 fl oz per cwt	None indicated							●		‡	●
lambda-cyhalothrin Grizzly Too Kendo Lambda-Cy EC LambdaStar Lambda-T Lamcap Nufarm Lambda Cyhalothrin 1EC Paradigm VC Province Silencer Silencer VXN Warrior II *RUP*	0.96 - 1.92 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 0.96 - 1.92 fl oz	7 days	●	*	●	*	●	●	●	●	●	
sulfoxaflor Transform WG[2]	0.75 oz	14 days	●									
thiamethoxam Helix Vibrance Helix XTra	**COMMERCIAL SEED TREATMENT ONLY** 23 fl oz per cwt	Do not graze or feed livestock on treated areas for 45 days							●			●
zeta-cypermethrin Mustang Maxx *RUP*	4 fl oz 4 fl oz	7 days	●	*	●	*	●	●	●	●	●	

RUP = Restricted Use Pesticide
● = Control
***** = Blister beetles and aster leafhoppers not listed on product labels, but should be controlled using labeled rates for other canola insects.
† = Control of first and second instar bertha armyworm only
‡ = Suppresion of second generation lygus bugs only
[2] = Transform WG: Do not apply this product until after petal fall. If blooming vegetation is present 12 feet out from the downwind edge of the field, a downwind 12-foot on-field buffer must be observed. Refer to label and www.isoclasttankmix.com for prohibited tank-mix partners.

CARROT INSECTS

ASTER LEAFHOPPER

Aster leafhopper can be a serious pest of carrots, potatoes and other vegetables. Feeding injury by the aster leafhopper is usually not the concern. It is the insect's ability to transmit Aster Yellows, a mycoplasma-induced disease. Aster Yellows can also affect wheat (symptoms resemble barley yellow dwarf). The aster leafhopper is light green. The head is marked with black spots arranged in pairs (which accounts for the other common name of "six-spotted leafhopper"). The aster leafhopper overwinters as an egg in the northern states. These eggs hatch sometime in June. However, by late May and early June, adult leafhoppers are migrating into the region from areas to the south. In southern Minnesota and Wisconsin, the migrant adults are monitored for Aster Yellows infectivity levels. This information is useful for determining the population levels where growers need to control aster leafhopper to minimize infection and losses.

Thresholds: Sampling for leafhopper adults is done with a sweep net. When monitoring a field, estimate the population based on the average number of leafhoppers per 100 sweeps. In Wisconsin, based on a 2.5% infectivity level, control of aster leafhopper in carrots is currently recommended when sweep net sampling finds 20 leafhoppers per 100 sweeps for susceptible carrot varieties, or 40 per 100 sweeps for resistant carrot varieties.

WIREWORMS

Wireworms, although often serious pests of cereal grains in the seedling stage, seldom damage carrots. Cruiser and Gaucho are labeled as commercial seed treatment and use decisions must be made at time of seed purchase. Please the seed treatment section n the introduction for more information.

Carrot

INSECTICIDES REGISTERED FOR USE IN CARROTS

INSECTICIDE	PRODUCT PER ACRE	PHI	Aster Leafhopper	Wireworms
beta-cyfluthrin Baythroid XL *RUP*	1.6 - 2.8 fl oz	0 days	●	
beta-cyfluthrin + imicacloprid Leverage 360 *RUP*	2.4 - 2.8 fl oz	7 days	●	
carbaryl Sevin 4F Sevin XLR Plus	1 - 2 qts 1 - 2 qts	7 days	●	
cyfluthrin Tombstone Tombstone Helios *RUP*	1.6 - 2.8 fl oz 1.6 - 2.8 fl oz	0 days	●	
deltamethrin Delta Gold *RUP*	1.5 - 2.4 fl oz	3 days	●	
esfenvalerate Asana XL *RUP*	5.8 - 9.6 fl oz	7 days	●	
flupyradifurone Sivanto Prime	7 - 10.5 fl oz	7 days	●	
imidacloprid Attendant 480 FS Attendant 600 Gaucho 600 Dyna-Shield Imidacloprid 5 Senator 600 FS	**COMMERCIAL SEED TREATMENT ONLY** 8 fl oz per cwt 6.4 fl oz per cwt 6.4 fl oz per cwt 6.4 fl oz per cwt 6.4 fl oz per cwt	None indicated		●
imidacloprid Pasada 1.6F Prey 1.6 Sherpa	Foliar application: 3.5 fl oz	7 days	●	

INSECTICIDE	PRODUCT PER ACRE	PHI	Aster Leafhopper	Wireworms
imidacloprid ADAMA Alias 2F AmTide Imidacloprid 2F Malice 2F Montana 2F Nuprid 2SC Widow	Soil applications: 0.7 - 1.7 fl oz per 1,000 row-feet (10 - 24 fl oz per acre)	21 days	●	
imidacloprid AmTide Imidacloprid 2F Montana 2F Nuprid 2SC	Foliar application: 2.8 fl oz	7 days	●	
imidacloprid ADAMA Alias 4F Advise Four Montana 4F Nuprid 4F Max Wrangler	Soil applications: 0.35 - 0.85 fl oz per 1,000 row-feet (5 - 12 fl oz per acre)	21 days	●	
imidacloprid ADAMA Alias 4F Advise Four Montana 4F Nuprid 4F Max	Foliar application: 1.4 fl oz	7 days	●	
imidacloprid Admire Pro Nuprid 4.6F Pro	Soil application: 0.31 - 0.74 fl oz per 1,000 row-feet (4.4 - 10.5 fl oz per acre)	21 days	●	
imidacloprid Admire Pro	Foliar application: 1.2 fl oz	7 days	●	
imidacloprid Malice 75WSP	0.9 oz	7 days	●	
malathion Cheminova Malathion 57% Malathion 57 EC	1.5 - 2 pts 2.5 pts	7 days	●	
methomyl Lannate LV *RUP*	1.5 - 3 pts	1 day	●	
sulfoxaflor Transform WG	1.5 - 2.75 oz	7 days	●	
thiamethoxam Actara	1.5 - 3 oz	7 days	●	
thiamethoxam Platinum 75SG Platinum	1.7 - 4 oz 5 - 12 fl oz	None	●	
zeta-cypermethrin Mustang Maxx *RUP*	1.76 - 4 fl oz	1 day	●	

RUP = Restricted Use Pesticide
● = Control

Carrot

CORN INSECTS

Other Resources Available Through NDSU Extension Service:

Publications	E1852	Integrated Pest Management of Corn Rootworms in North Dakota (2017)
	E830	The Armyworm and the Army Cutworm (revised 2018)

APHIDS

Corn Leaf and Greenbug

The greenbug and corn leaf aphid are the most common aphid species causing problems in corn and sorghum. The greenbug is the most injurious because it injects a toxin with its saliva during feeding.

Threshold: The critical period for injury by corn leaf aphid is during tassel emergence through pollination. Treatment is suggested only when 50% of the corn plants have 100+ aphids per plant during tassel emergence and plants are drought stressed.

Natural Controls: Lady beetles, aphid lions, syrphid fly and parasitic wasps play a major role in reducing aphid populations. When natural enemies are present in large numbers, and the crop is well developed, farmers are discouraged from spraying fields.

ARMYWORMS

Armyworm outbreaks in North Dakota can occur when large migrations of moths from Southern states occur in late spring and early summer. Moths prefer to lay eggs in moist, shady areas where small grains or grasses have lodged or been damaged by hail or wind. Armyworms feed at night and hide under vegetation or in loose soil during the day. To scout for armyworms in grains, part the plants and inspect the soil for fecal pellets. If pellets or feeding damage are found, look for larvae under plant trash, soil clods or in soil cracks.

Threshold: Treat when 25% to 30% of the plants have 2 or more worms **or** 75% of the plants have 1 worm.

Migrating Armyworms: Treat a couple of swaths ahead of the infestation in the direction of movement to form a barrier strip.

CORN ROOTWORM LARVAE

Rootworm larvae injure the root system of the corn plant. Yield potential may be reduced and/or lodging of plants may occur. Annual crop rotation from corn should prevent serious damage and losses. Early planting of corn allows for better root development prior to the late June hatch of rootworm eggs.

Threshold: Corn plants can be dug in August to examine roots for rootworm feeding injury. Use the Iowa State University root rating scale of 0-3 for assessing corn rootworm damage: 0 = no injury; 1 = one complete node (about 10 roots) is pruned to within 1.5 inches of the stalk; 2 = two complete nodes (about 20 roots) is pruned to within 1.5 inches of the stalk; and 3 = three complete nodes (about 30 roots) is pruned to within 1.5 inches of the stalk. A root rating of 0.25 is considered to cause economic loss. For Bt hybrids, a root injury rating that exceeds 1.0 would be unexpected and suggests corn rootworm resistance to that Bt trait. To prevent development of corn rootworm resistance to Bt traits, use crop rotation, rotation of Bt traits, control volunteer corn in soybean and other field crops and rotations to soil-applied insecticide without a Bt trait. See website (below) from Iowa State University for an *Interactive Node-Injury Scale* for assessing corn rootworm larval feeding injury on roots.

http://www.ent.iastate.edu/pest/rootworm/nodeinjury/nodeinjury.html

CORN ROOTWORM ADULTS

The decision to rotate from corn or to use an insecticide / Bt corn hybrids for corn rootworm management may be based on field scouting for adult beetles. Record the number of corn rootworm beetles on the foliage and silk of 100 plants. Rootworm beetles feed on the leaves, silk and pollen of corn during a three week period after pollination. Occasionally, the beetles congregate and feed on silks during early pollen shed. If silks are chewed back to the tips of ears (less than 1/2 inch of silks protruding) during the period of maximum pollen shed, poor pollination and grain set can occur. Adult injury to corn silks is uncommon in North Dakota.

Threshold: Treat field with a foliar insecticide for adult beetles, when an average of 5 or more beetles per silk mass is found, silks are being clipped to within ½ inch of the ear tip, and when pollination is not complete (<50%). When the adult population averages 1 beetle per plant in continuous corn or 0.5 beetles per plant in first-year corn fields, the potential for larval root damage the next summer is sufficient to rotate from corn or to apply an insecticide.

CUTWORMS

Several cutworm species affect regional crops. The dingy cutworm, *Feltia jaculifera*, overwinters as a partially grown larva and is one of the first cutworm species to cause problems during crop emergence from early to mid-May. The moth of the dingy cutworm is known to lay her eggs on sunflower heads from mid-July through September. Crops following sunflowers in rotation are at greatest risk of injury by this cutworm. Other cutworms, the red-backed, *Exoa ochregaster*, and the darksided, *Exoa messoria*, overwinter as eggs which hatch in mid to late May. Eggs are laid in the fall and survive in weedy, wet, and reduced tillage areas. Feeding injury by these cutworms normally occurs in late May to early June. Some criteria that may help predict cutworm problems are: 1) field history of cutworm damage; 2) surface crop residue from reduced or minimum tillage; 3) bottom land or low spots in field; 4) fair to poor drainage; 5) near shelterbelts with grassy ground cover. Because eggs of the important cutworms are laid during late summer in North Dakota, soil moisture at this time is important for their winter survival. Growers should be cautious when planting corn following pasture, alfalfa, or clover sites; survival may be greater at these locations.

Thresholds: Begin scouting for cutworms when corn is up to a stand and continue until mid-June. **When 2% to 3% of the plants are cut and small larvae (<¾ inch) are present, a treatment is justified. The threshold increases to 5% cut plants when larvae are >¾ inch.** Application rate of 15 to 20 gallons of water per acre by ground application is recommended. Cutworm larvae feed actively at night, so an evening insecticide application is best.

EUROPEAN CORN BORER

Managing corn borer in North Dakota is a challenge due to the lengthy emergence interval of the moths from overwintering. In North Dakota, borers have the potential for one or two generations during the season. The two generation borers are present in the southern region of the state. They begin emerging in early June and represent the first flush of larval feeding. The single-generation borer is present throughout North Dakota, emerging from mid-June to August. The challenge of the crop manager is to distinguish when egg laying and larval populations can be tolerated or if they need to be controlled. Corn should be monitored weekly for ***at least* five weeks** once plants exceed an extended leaf height of 17 inches. At this point, corn borer larvae will be able to survive on the plant. Inspect plants for the presence of egg masses, whorl feeding, and active larvae. Observing moth activity around field margins or within the field may alert you to developing infestations. Recent corn borer infestations in North Dakota developed in mid to late July and August as a result of the late emergence of the numerous single-generation type borers. In other years, the two- generation borers emerging first may contribute more to significant infestations.

Field scouting for corn borers:

Whorl stage corn . . . . Pull the whorls from 10 plants at 5 locations across the field. Select whorls at random, avoiding damaged plants. Unwrap the whorl leaves; count and record the number of live larvae found.

Worksheet for whorl stage corn -- You fill in the blanks

1. __ % of plants infested x __ Avg no. borers/plant = __ Borers per plant
2. __ borers per plant x __ percent yield loss per borer* = __ percent yield loss
3. __ percent yield loss x __ expected yield (bu. per acre) = __ bushels per acre loss
4. __ bushel loss per acre x __ price per bushel = $ __ loss per acre
5. __ loss per acre x __ percent control** = $ __ preventable loss/a
6. __ preventable loss/acre- __ cost of control per acre = $ __ profit (loss)/acre

*5% for corn in the early whorl stage; 4% for late whorl; 6% for pretassel
**80% for granules; 75% for sprays.

Tassel stage or older corn . . . . Examine the underside of the middle 7 leaves (3 leaves above and 3 leaves below the ear leaf) on 20 plants from 5 locations in the field. Multiply the number of egg masses found by 1.1 (correction factor for eggs on other leaves). Complete worksheet to determine the need for treatment.

Worksheet for tassel stage or older corn -- You fill in the blanks

1. __ egg masses per plant* x 4.5 borers per egg mass = ___ borers per plant
2. __ borers per plant x __ percent yield loss per borer** = ___ percent yield loss
3. __ percent yield loss x __ expected yield (bu. per acre) = ___ bushels per acre loss
4. __ bushel loss per acre x __ price per bushel = $ ___ loss per acre
5. __ loss per acre x 80 percent control = $ ___ preventable loss/acre
6. __ preventable loss/acre - __ cost of control per acre = $ ___ profit (loss) / acre

*Cumulative counts taken five to seven days later can be added here
**Use 0.04 for pollen-shedding corn, 0.03 if kernels are initiated

Economic Threshold (Corn Borer/plant) When Factoring Crop Value and Control Costs

Control Costs[2] ($/acre)	Value of Corn Crop1 ($/acre)								
	200	250	300	350	400	450	500	550	600
6	0.75	0.60	0.50	0.43	0.38	0.34	0.30	0.27	0.25
7	0.88	0.70	0.58	0.50	0.44	0.39	0.35	0.32	0.29
8	1.00	0.80	0.67	0.57	0.50	0.45	0.40	0.37	0.34
9	1.12	0.90	0.75	0.64	0.56	0.50	0.45	0.41	0.38
10	1.25	1.00	0.83	0.71	0.63	0.56	0.50	0.46	0.42
11	1.38	1.10	0.92	0.79	0.69	0.61	0.55	0.50	0.46
12	1.50	1.20	1.00	0.86	0.75	0.67	0.60	0.55	0.50
13	1.63	1.30	1.08	0.93	0.81	0.72	0.65	0.59	0.54
14	1.75	1.40	1.17	1.00	0.88	0.78	0.70	0.64	0.59
15	1.88	1.50	1.25	1.07	0.94	0.84	0.75	0.68	0.63
16	2.00	1.60	1.33	1.14	1.00	0.89	0.80	0.73	0.68

[1] *Crop value = expected yield (bu/acre) X projected price ($/bu)*
[2] *Control costs = insecticide price ($/acre) + application costs ($/acre)*

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The Handy Bt Trait Table

for U.S. Corn Production

The latest version of the table is always posted at https://www.texasinsects.org/bt-corn-trait-table.html

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Updated May 2019

The Handy Bt Trait Table provides a helpful list of trait names (below) and details of trait packages (over) to make it easier to understand company seed guides, sales materials, and bag tags. This latest version incorporates two new findings of resistance, and categorizes western & northern corn rootworm separately.

Breaking News #1: Entomologists at the University of Guelph in Canada confirmed European corn borer (ECB) resistance to Cry1F Bt (the Herculex I trait) in corn. In 2018, ECB populations were collected from multiple locations in the Maritime Provinces of eastern Canada where unexpected damage was reported. Lab bioassays showed a high level of resistance to Cry1F; the registrant of the trait independently confirmed the results. *This is the first case of field-evolved resistance by ECB to Bt corn.*

Use of single-trait hybrids likely contributed to the problem. In eastern Canada, hybrids with only one Bt trait (Cry1F) were still being sold & planted, well after an expected phase out in favor of multi-Bt pyramids to allow for reduced 5% refuge. Although the Maritime provinces are far from the major corn production area in the central U.S., the bioassay results demonstrate that ECB resistance to Bt corn can happen, and that phasing out single-trait hybrids is critical. In short-growing season areas of the U.S. and Canada, seed options tend to be limited, so single-trait hybrids may still be available. Using them risks the development of additional resistant insect populations.

Breaking News #2: Entomologists at North Dakota State University confirmed northern corn rootworm resistance to Cry3Bb1 and Cry34Ab1/Cry35Ab1. Although resistance to multiple traits is well-documented in the Midwest for western corn rootworm, this is the *first confirmation of field-evolved resistance by the northern corn rootworm*.

Field corn 'events' (transformations of one or more genes) and their Trade Names

Trade name for trait	Event	Protein(s) expressed	Primary Insect Targets + *Herbicide tolerance*
Agrisure CB/LL	Bt11	Cry1Ab + *PAT*	corn borer + *glufosinate*
Agrisure Duracade	5307	eCry3.1Ab	rootworm
Agrisure GT	GA21	*EPSPS*	*glyphosate*
Agrisure RW	MIR604	mCry3A	rootworm
Agrisure Viptera	MIR162	Vip3Aa20	broad caterpillar control, except for corn borer
Enlist	DAS40278	*aad-1*	*2,4-D herbicide detoxification*
Herculex I (HXI) or CB	TC1507	Cry1Fa2 + *PAT*	corn borer + *glufosinate*
Herculex CRW	DAS-59122-7	Cry34Ab1/Cry35Ab1 + *PAT*	rootworm + *glufosinate*
(None – part of Qrome)	DP-4114	Cry1F + Cry34Ab1/Cry35Ab1 + *PAT*	corn borer + rootworm + *glufosinate*
Roundup Ready 2	NK603	*EPSPS*	*glyphosate*
Yieldgard Corn Borer	MON810	Cry1Ab	corn borer
Yieldgard Rootworm	MON863	Cry3Bb1	rootworm
Yieldgard VT Pro	MON89034	Cry1A.105 + Cry2Ab2	corn borer & several caterpillar species
Yieldgard VT Rootworm	MON88017	Cry3Bb1 + *EPSPS*	rootworm + *glyphosate*

Abbreviations used in the Trait Table

Herbicide traits

GT *glyphosate tolerant*
LL Liberty Link - *glufosinate-tolerant*
RR2 Roundup Ready 2, *glyphosate-tolerant*

Insect targets

BCW black cutworm
CEW corn earworm
ECB European corn borer
FAW fall armyworm
SB stalk borer
SCB sugarcane borer
SWCB southwestern corn borer
TAW true armyworm
WBC western bean cutworm
CR corn rootworm (NCR = Northern & WCR = Western)

Corn

The Handy Bt Trait Table for U.S. Corn Production, updated May 2019

Trait packages in alphabetical order (acronym)	Bt protein(s) in the trait package	Marketed for control of: BCW	CEW	ECB	FAW	SB	SCB	SWCB	TAW	WBC	CR	Resistance confirmed to the combination of Bts in package (check local situation)	Herbicide trait GT RR2	Herbicide trait LL	Non-Bt Refuge % (cornbelt)
AcreMax (AM)	Cry1Ab Cry1F	x		x	x	x	x	x				FAW WBC	x	x	5% in bag
AcreMax CRW (AMRW)	Cry34/35Ab1										x	NCR/WCR	x	x	10% in bag
AcreMax1 (AM1)	Cry1F Cry34/35Ab1	x		x	x	x	x	x			x	ECB FAW SWCB WBC NCR/WCR	x	x	10% in bag 20% ECB
AcreMax Leptra (AML)	Cry1Ab Cry1F Vip3A	x	x	x	x	x	x	x	x	x			x	x	5% in bag
AcreMax TRIsect (AMT)	Cry1Ab Cry1F mCry3A	x		x	x	x	x	x			x	FAW WBC WCR	x	x	10% in bag
AcreMax Xtra (AMX)	Cry1Ab Cry1F Cry34/35Ab1	x		x	x	x	x	x			x	FAW WBC NCR/WCR	x	x	10% in bag
AcreMax Xtreme (AMXT)	Cry1Ab Cry1F mCry3A Cry34/35Ab1	x		x	x	x	x	x			x	FAW WBC WCR	x	x	5% in bag
Agrisure 3010 and 3010A	Cry1Ab			x			x	x					x	x	20%
Agrisure 3000GT and 3011A	Cry1Ab mCry3A			x			x	x			x	WCR	x	x	20%
Agrisure Viptera 3110	Cry1Ab Vip3A	x	x	x	x	x	x	x	x	x			x	x	20%
Agrisure Viptera 3111	Cry1Ab Vip3A mCry3A	x	x	x	x	x	x	x	x	x	x	WCR	x	x	20%
Agrisure 3120 E-Z Refuge	Cry1Ab Cry1F	x		x	x	x	x	x				FAW WBC	x	See bag tag for code	5% in bag
Agrisure 3122 EZ Refuge	Cry1Ab Cry1F mCry3A Cry34/35Ab1	x		x	x	x	x	x			x	FAW WBC WCR	x		5% in bag
Agrisure Viptera 3220 E-Z Refuge	Cry1Ab Cry1F Vip3A	x	x	x	x	x	x	x	x	x			x		5% in bag
Agrisure Viptera 3330 E-Z Refuge	Cry1Ab Vip3A Cry1A.105 + Cry2Ab2	x	x	x	x	x	x	x	x	x			x	EZ0 NO	5% in bag
Agrisure Duracade 5122 E-Z Refuge	Cry1Ab Cry1F mCry3A eCry3.1Ab	x		x	x	x	x	x			x	FAW WBC WCR	x	EZ1 YES	5% in bag
Agrisure Duracade 5222 E-Z Refuge	Cry1Ab Cry1F Vip3A mCry3A eCry3.1Ab	x	x	x	x	x	x	x	x	x	x	WCR	x		5% in bag
Herculex I (HXI)	Cry1F	x		x	x	x	x	x				ECB FAW SWCB WBC	x	x	20%
Herculex RW (HXRW)	Cry34/35Ab1										x	NCR/WCR	x	x	20%
Herculex XTRA (HXX)	Cry1F Cry34/35Ab1	x		x	x	x	x	x			x	ECB FAW SWCB WBC NCR/WCR	x	x	20%
Intrasect (YHR)	Cry1Ab Cry1F	x		x	x	x	x	x				FAW WBC	x	x	5%
Intrasect TRIsect (CYHR)	Cry1Ab Cry1F mCry3A	x		x	x	x	x	x			x	FAW WBC WCR	x	x	20%
Intrasect Xtra (YXR)	Cry1Ab Cry1F Cry34/35Ab1	x		x	x	x	x	x			x	FAW WBC NCR/WCR	x	x	20%
Intrasect Xtreme (CYXR)	Cry1Ab Cry1F mCry3A Cry34/35Ab1	x		x	x	x	x	x			x	FAW WBC WCR	x	x	5%
Leptra (VYHR)	Cry1Ab Cry1F Vip3A	x	x	x	x	x	x	x	x	x			x	x	5%
Powercore [a] Powercore Refuge Advanced [b]	Cry1A.105 Cry2Ab2 Cry1F	x	x	x	x	x	x	x				CEW WBC	x	x	[a] 5% [b] 5% in bag
QROME (Q)	Cry1Ab Cry1F mCry3A Cry34/35Ab1	x		x	x	x	x	x			x	FAW WBC WCR	x	x	5% in bag
SmartStax [a] Smartstax Refuge Advanced [b] SmartStax RIB Complete [b]	Cry1A.105 Cry2Ab2 Cry1F Cry3Bb1 Cry34/35Ab1	x	x	x	x	x	x	x			x	CEW WBC WCR	x	x	[a] 5% [b] 5% in bag
Trecepta [a] Trecepta RIB Complete [b]	Cry1A.105 Cry2Ab2 Vip3A	x	x	x	x	x	x	x	x	x			x		[a] 5% [b] 5% in bag
TRIsect (CHR)	Cry1F mCry3A	x		x	x	x	x	x			x	ECB FAW SWCB WBC WCR	x	x	20%
VT Double PRO [a] VT Double PRO RIB Complete [b]	Cry1A.105 Cry2Ab2		x	x	x	x	x	x				CEW	x		[a] 5% [b] 5% in bag
VT Triple PRO [c] VT Triple PRO RIB Complete [d]	Cry1A.105 Cry2Ab2 Cry3Bb1		x	x	x	x	x	x			x	CEW NCR/WCR	x		[c] 20% [d] 10% in bag
Yieldgard Corn Borer (YGCB)	Cry1Ab			x			x	x					x		20%
Yieldgard Rootworm (YGRW)	Cry3Bb1										x	NCR/WCR	x		20%
Yieldgard VT Triple	Cry1Ab Cry3Bb1			x			x	x			x	NCR/WCR	x		20%

Corn

GRASSHOPPERS

In the Northern Plains, grasshopper egg hatch normally begins in late April to early May. Peak hatch occurs about mid-June. Heavy infestations typically occur in areas of low rainfall or during drought years. Outbreaks are usually preceded by several years of hot, dry summers and warm autumns. Cool, wet weather increases disease occurrence and delays development of grasshoppers, reducing the overall population.

Thresholds: The threatening rating is considered the action threshold for grasshoppers. Since it is difficult to estimate the number of grasshoppers per square yard when population densities are high, pest managers can use four 180-degree sweeps with a 15-inch sweep net, which is equivalent to the number of adult (or nymph) grasshoppers per square yard.

	Nymphs per square yard		**Adults per square yard**	
Rating	Margin	Field	Margin	Field
Light	25-35	15-25	10-20	3-7
Threatening	50-75	30-45	21-40	8-14
Severe	100-150	60-90	41-80	15-28
Very Severe	200+	120+	80+	28+

SPIDER MITES

Mites are small and magnification is required to see them. A quick sampling procedure to determine whether mites are present is to hold a piece of white paper below leaves then slap them to dislodge the mites. Or, pulling plants and examining the underside of the leaves from the bottom of plants upwards. The mites appear as tiny dust specks; however, they will move after being knocked off the leaf. Feeding damage by mites first appears as small yellow spots ("stippling"). As feeding activity increases, leaves become yellow, bronzed or brown, and eventually shed from the plant. Mite webbing may be present on plants as mites balloon on webs to disperse within field. Be sure to scout during tasseling through hard dough stages since these crop stages are susceptible to yield loss from spider mites.

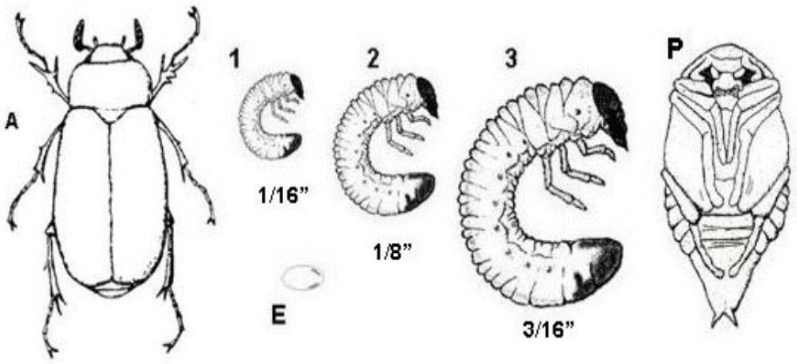
Mites usually become a problem when hot, dry weather occurs. Infestations typically are first noted near field edges. These environmental conditions stress the plant, whether mites are present or not. If conditions continue, treating for mites is no guarantee plants will recover. In addition, products labeled for mite control often do not give adequate control and the population of mites may rebound quickly to pretreatment levels or higher. When rain and humidity are present, natural reductions in mite populations occur due to infection by a fungal pathogen. Conditions that are good for the development of the pathogen are temperatures cooler than 85º F, with at least 90% R.H. for 12 to 24 hours.

Threshold: Deciding whether to treat is difficult. There is no specific threshold that has been developed for two-spotted spider mite in soybean. Sample plants at least 100 feet into the field and walk in a “U” pattern sampling two plants per location at 20 different locations. A general action threshold is to treat when the lower ¼ to ⅓ of canopy has mite damage symptoms and/or mites present. Avoid letting mite damage reach the ear leaves (Source: University of Minnesota, Ostlie & Potter).

Remember to use an organophosphate insecticide (e.g. Dimethoate) over a pyrethroid insecticide to avoid flaring mite populations. However, the active ingredient, bifenthrin (pyrethroid) does not flare mite populations. Miticides (etoxazole, propargite, spiromesifen) are labeled on field corn. Reasons for the increase in mite populations from some pyethroids include: disruption of the natural enemies that control spider mites (predatory mites); increased movement of mites out of fields, and increased reproductive rates of female mites. Early detection facilitates timely and effective rescue treatments. Current insecticides for corn provide short-term protection, maybe 7 days, from the pest. Fields will need to be re-monitored continually for resurging populations. The efficacy of an insecticide can be improved significantly with sufficient coverage >18 GPA of water by ground and 3-5 GPA by air and application at high pressure to penetrate foliage. For insecticide resistance management of mites, do not apply the same class of insecticide/miticide (or mode of action) more than twice and alternate the class of the insecticides/miticide (or mode of action) to prevent buildup of resistant mite strains.

WHITE GRUBS (LARVAE)

White grubs that are destructive to field crops in North Dakota have a three-year life cycle. In southeast North Dakota, the most common white grub pest occurs in continuous cropping situations at sites where willow and cottonwood trees are present. In other areas of the state, white grubs are most likely to be found when rotations from grassland, pasture, or grassy weed sites occur. Most root feeding occurs in the second year of the life cycle. In most cases, the number of second-year grubs will only be great enough to justify control once every three years.



Life stages of Phyllophaga implicita: A - adult June beetle; E - egg; grub stages with their head width in inches, 1 - first; 2 - second; 3 - third; and P - pupa.

Thresholds: Treatment is recommended when sampling indicates an average of one or more white grubs per square foot are found. The following sampling procedure provides treatment decisions based on this guideline.

Soil sampling: Fields need to be sampled to determine grub abundance and aid in determining if control is necessary. Sampling in late summer or early fall, before a freeze, provides a more reliable estimate of populations than spring sampling just before planting. Larvae are typically present in the upper 6 inches of soil until a killing frost occurs in the fall. Take soil samples, 1 square foot in size to a depth of 8 inches. Begin taking samples 45 yards from shelterbelts. A total of 30 samples per field, randomly spaced along the shelterbelts, are necessary. If at least a single grub is found in less than 40% of the samples, treatment may be required only out 20 yards from the tree line. If 40% to 60% of the samples are infested, treatment is needed to this distance and maybe as far as 65 yards. If greater than 60% of the samples are infested, treatment may be needed out to 90 yards from the tree line.

WIREWORMS

Wireworms are most likely to be problems when corn follows pasture or grassland. Continuous corn has developed problems in the past, also. Infestations often are found in coarse textured soils (sandy loam) where moisture is abundant, perhaps in low spots of fields.

Thresholds: There is no easy way to estimate wireworm infestations. Two methods are currently used.

***Soil Sampling*:** Sample 20, well spaced, 1 square foot sites to a depth of 4 to 6 inches for every 40 acres being planted. If an average of 1 wireworm per square foot is found, treatment would be justified.

***Solar Baiting*:** In September, establish bait stations for 2 to 3 weeks before freeze. Place bait stations randomly through the field, but representing all areas of the field. There should be 10 - 12 stations per 40 acre field. Place one cup wheat and one cup shelled corn in a 4- to 6-inch deep hole. Cover grain with soil and then an 18-inch square piece of clear plastic. Dig up the grain. If an average of one or more wireworm larvae is found per station, treatment would be justified.

Seed Treatment: Seed treatments and/or planter box treatments are available for use on corn for managing wireworm. Please the seed treatment section in the introduction for more information.

INSECTICIDES REGISTERED FOR USE IN CORN

INSECTICIDE	PRODUCT PER ACRE	PHI	Aphids	Armyworms	Corn Rootworm Larvae	Corn Rootworm Adults	Cutworms	European Corn Borer	Grasshoppers	White Grubs	Wireworms	Spider mites
abamectin + thiamethoxam Avicta Complete Corn (Combination of insecticide and fungicide products) *RUP*	See individual product labels for rates and use directions (Avicta Duo Corn, Cruiser, Apron XL and/or Dynasty)	See individual product labels			●					●	●	
alpha-cypermethrin Fastac CS Fastac EC *RUP*	At Plant: 0.15 fl oz per 1,000 row feet	30 days for grain and stover 60 days for forage					●					
alpha-cypermethrin Fastac CS Fastac EC *RUP*	Foliar Application: 1.3 - 3.8 fl oz	30 days for grain and stover 60 days for forage		●		●	●	●	●			
Bacillus thuringiensis Biobit HP DiPel DF DiPel ES XenTari DF	0.5 - 2 lbs 0.5 - 2 lbs 0.5 - 2.5 pts 0.5 - 2	None		‡				●				
beta-cyfluthrin Baythroid XL *RUP*	At Plant: 0.12 - 0.16 fl oz per 1,000 row-feet (2 - 2.8 fl oz per acre)	21 days for grain and fodder								●	●	
beta-cyfluthrin Baythroid XL *RUP*	Foliar Application: 0.8 - 2.8 fl oz	21 days for grain and fodder		●		●	●	●	●			
bifenthrin Bifen 2 AG Gold Bifenthrin 2EC Bifenture EC Brigade 2EC Discipline 2EC Fanfare 2EC Sniper Sniper Helios Tundra EC *RUP*	At Planting: 0.15 - 0.3 fl oz per 1,000 row-feet Pre-plant Broadcast: 2.56 fl oz per acre Pre-plant Incorporated: 3 - 4 fl oz per acre	30 days for grain and feed		●	●		●			●	●	
bifenthrin Bifender FC Bifen 2 AG Gold Bifenthrin 2EC Bifenture EC Brigade 2EC Discipline 2EC Fanfare 2EC Sniper Sniper Helios Tundra EC *RUP*	Foliar Application: 2.4 - 7.4 fl oz 2.1 - 6.4 fl oz 2.1 - 6.4 fl oz 2.1 - 6.4 fl oz 2.1 - 6.4 fl oz 2.1 - 6.4 fl oz 2.1 - 6.4 fl oz 2.1 - 6.4 fl oz 2.1 - 6.4 fl oz 2.1 - 6.4 fl oz	30 days for grain and feed	●			●	●	●	●			

Corn

INSECTICIDE	PRODUCT PER ACRE	PHI	Aphids	Armyworms	Corn Rootworm Larvae	Corn Rootworm Adults	Cutworms	European Corn Borer	Grasshoppers	White Grubs	Wireworms	Spider mites
bifenthrin Bifender FC *RUP*	At Planting: 0.17 - 0.84 fl oz per 1,000 row-feet Pre-plant Broadcast (armyworm and cutworm): 2.9 - 11.8 fl oz per acre Pre-plant Incorporated (armyworm and cutworm): 3.5 - 4.6 fl oz per acre	None listed		●	●		●			●	●	
bifenthrin Capture LFR Ethos XB Sniper LFR *RUP*	At Planting: 0.2 - 0.98 fl oz per 1,000 row-feet Pre-plant Broadcast (armyworm and cutworm): 3.4 fl oz per acre Pre-plant Incorporated (armyworm and cutworm): 4 - 5.3 fl oz per acre	None listed		●	●		●			●	●	
bifenthrin Ethos LFR *RUP*	At Planting: 0.49 - 1.09 fl oz per 1,000 row-feet	None listed		●	●		●			●	●	
bifenthrin + chlorethoxyfos SmartChoice 5G Lock n Load *RUP*	3 - 5 oz per 1,000 row-feet	None			●		●			●	●	
bifenthrin + chlorpyrifos Tundra Supreme *RUP*	5.6 – 16.8 fl oz	30 days for grain and forage	●	●		●	●	●	●			
bifenthrin + zeta-cypermethrin Hero *RUP*	At Plant: 4 - 10.3 fl oz	30 day for grain, 60 days for forage		●			●			●	●	
bifenthrin + zeta-cypermethrin Hero *RUP*	Foliar: 4 - 10.3 fl oz	30 day for grain, 60 days for forage	●	●		●	●	●	●			
carbaryl Sevin 4F Sevin XLR Plus	1 - 2 qts 1 - 2 qts	48 days for grain and fodder 14 days for grazing and forage		●		●	●	●				
chlorantraniliprole Coragen Prevathon	3.5 - 5 fl oz 14 - 20 fl oz	14 days 14 days, 1 day for forage, fodder, silage, stover		●				●				
chlorantraniliprole + lambda-cyhalothrin Besiege *RUP*	5 - 10 fl oz	21 days	●	●		●	●	●	●			
chlorpyrifos Lorsban 15G	Soil Applications: 8 oz per 1,000 row-feet or 5 - 6.5 lbs per acre	21 days		●	●		●	●		●	●	

Corn

INSECTICIDE	PRODUCT PER ACRE	PHI	Aphids	Armyworms	Corn Rootworm Larvae	Corn Rootworm Adults	Cutworms	European Corn Borer	Grasshoppers	White Grubs	Wireworms	Spider mites
chlorpyrifos Warhawk Whirlwind *RUP*	PPI: 2 - 6 pts	21 days for grain, forage and fodder			●		●			●	●	
chlorpyrifos Chlorpyrifos 4E AG Govern 4E Hatchet Lorsban 4E Lorsban Advanced Nufos 4E Vulcan Warhawk Whirlwind Yuma 4E *RUP*	At Plant and PRE (Conservation Tillage): 1 - 2 pts	21 days for grain, forage and fodder		●			●					
chlorpyrifos Chlorpyrifos 4E AG Govern 4E Hatchet Lorsban 4E Lorsban Advanced Nufos 4E Vulcan Warhawk Whirlwind Yuma 4E *RUP*	Foliar: 0.5 - 2 pts	21 days for grain, forage and fodder	●	●		●	●	●	●			
chlorpyrifos + bifenthrin Match-Up *RUP*	Preemerge Broadcast: 6.6 fl oz/a At Plant T-band: 0.4 - 0.8 fl oz/1,000 row feet Foliar: 5.5 - 16.4 fl oz	30 days for grain, forage and feed	●	●	●	●	●	●	●	●	●	●
chlorpyrifos + lambda-cyhalothrin Cobalt Advanced *RUP*	At Plant: 1.89 - 3.8 fl oz per 1,000 row-feet	21 days for grain, forage and fodder					●			●	●	
chlorpyrifos + lambda-cyhalothrin Cobalt Advanced *RUP*	32 - 42 fl oz Apply at cultivation or through sprinkler irrigation	21 days for grain, forage and fodder			●							
chlorpyrifos + lambda-cyhalothrin Cobalt Advanced *RUP*	Foliar Application: 6 - 38 fl oz	21 days for grain, forage and fodder	●	●		●	●	●	●			
cholrpyrifos + zeta-cypermethrin Stallion *RUP*	At Plant: 11.75 fl oz per acre Consult label for rate per 1,000 row-feet	30 days for grain, 60 days for forage					●					
cholrpyrifos + zeta-cypermethrin Stallion *RUP*	Foliar Application 3.75 - 11.75 fl oz	30 days for grain, 60 days for forage	●	●		●	●	●	●			

Corn

INSECTICIDE	PRODUCT PER ACRE	PHI	Aphids	Armyworms	Corn Rootworm Larvae	Corn Rootworm Adults	Cutworms	European Corn Borer	Grasshoppers	White Grubs	Wireworms	Spider mites
clothianidin Poncho 600 NipsIt Inside	**COMMERCIAL SEED TREATMENT ONLY** 1.13 - 5.64 fl oz per 80,000 seed unit Use high rate for corn rootworm larvae	None			●					●	●	
clothianidin + *Bacillus firmus* Poncho Votivo	**COMMERCIAL SEED TREATMENT ONLY** 2.7 fl oz per 80,000 seed unit	None			●					●	●	
cyantraniliprole Fortenza	**COMMERCIAL SEED TREATMENT ONLY** 0.125 - 0.5 mg ai per seed	None. Consult label for rotational crop restrictions.		●			●			●	●	
cyfluthrin Tombstone Tombstone Helios *RUP*	At Plant: 0.12 - 0.16 fl oz per 1,000 row-feet	21 days for grain and fodder								●	●	
cyfluthrin Tombstone Tombstone Helios *RUP*	Foliar: 0.8 - 2.8 fl oz	21 days for grain and fodder		●		●	●	●	●			
cyfluthrin + tebupirimiphos Aztec 2.1G *RUP*	6.7 oz per 1,000 row-feet	None			●		●			●	●	
cyfluthrin + tebupirimiphos Aztec 4.67G *RUP*	**FOR USE IN SMARTBOX SYSTEM ONLY** 3 oz per 1,000 row-feet	None			●		●			●	●	
deltamethrin Delta Gold *RUP*	0.8 - 1.9 fl oz	21 days for grain, 12 days for grazing and forage	●	●		●	●	●	●			
dimethoate Dimate 4E Dimethoate 4E Dimethoate 4EC Dimethoate 400	0.67 - 1 pt	28 days for grain 14 days for forage	●			●			●			
esfenvalerate Asana XL *RUP*	5.8 - 9.6 fl oz	21 days	●	●		●	●	●	●			
etoxazole Zeal SC Zeal WDG	2 - 6 fl oz 1 - 3 fl oz	21 days Do not make >2 applications per season Do not make applications less than 14 days apart										●
fipronil Regent 4SC *RUP*	0.24 fl oz per 1,000 row-feet (30" row spacing) See label for rates at different row spacings	90 days			●					●	●	
flupyradifurone Sivanto Prime	7 - 10.5 fl oz	7 days for forage 21 days grain, stover and straw	●									
gamma-cyhalothrin Declare *RUP*	At Plant: 0.26 fl oz per 1,000 row-feet	21 days			●		●			●	†	

Corn

INSECTICIDE	PRODUCT PER ACRE	PHI	Aphids	Armyworms	Corn Rootworm Larvae	Corn Rootworm Adults	Cutworms	European Corn Borer	Grasshoppers	White Grubs	Wireworms	Spider mites
gamma-cyhalothrin Declare *RUP*	Foliar: 0.77 - 1.54 fl oz	21 days	●	●		●	●	●	●			
imidacloprid Attendant 600 Dyna-Shield Imidacloprid 5 Gaucho 600 Senator 600FS	0.72 - 6 fl oz per 80,000 seed unit Use high rate for corn rootworm (protection not adequate in heavy corn rootworm populations)	None	●		●			●		●	●	
indoxacarb Stewart EC	6 - 11.3 fl oz	14 days for grain and stover, 1 day for forage, fodder, silage		●		●		●	●			
lambda-cyhalothrin Kendo Nufarm Lamda Cyhalothrin 1EC Lambda-Cy EC LambdaStar Lambda-T Lamcap Paradigm VC Province Silencer Silencer VXN *RUP*	At Plant: 0.66 fl oz per 1,000 row-feet	21 days for grain, fodder and silage, 1 day for grazing			●		●			●	●	
lambda-cyhalothrin Kendo Nufarm Lamda Cyhalothrin 1EC Lambda-Cy EC LambdaStar Lambda-T Lamcap Paradigm VC Province Silencer Silencer VXN *RUP*	Foliar: 1.92 - 3.84 fl oz	21 days for grain, fodder and silage, 1 day for grazing	†	●		●	●	●	●			
lambda-cyhalothrin Grizzly Too Warrior II *RUP*	At Plant: 0.33 fl oz per 1,000 row-feet	21 days for grain, fodder and silage, 1 day for grazing			●		●			●	●	
lambda-cyhalothrin Grizzly Too Warrior II *RUP*	Foliar: 0.96 - 1.92 fl oz	21 days for grain, fodder and silage, 1 day for grazing	●	●		●		●	●			
malathion Cheminova Malathion 57% Malathion 5	1.5 pts 1 - 2 pts	7 days	●	‡		●			●			
malathion Fyfanon ULV AG	4 - 8 fl oz	5 days	●			●			●			
methomyl Lannate LV *RUP*	**Consult current label for use restrictions** 0.75 - 1.5 pts	21 days for grain 3 days for forage	●	●		●	●	●				
methoxyfenozide Intrepid 2F	4 - 16 fl oz	21 days		●				●				

Corn

INSECTICIDE	PRODUCT PER ACRE	PHI	Aphids	Armyworms	Corn Rootworm Larvae	Corn Rootworm Adults	Cutworms	European Corn Borer	Grasshoppers	White Grubs	Wireworms	Spider mites
permethrin Pounce 1.5G *RUP*	Soil applications: 8 - 16 oz per 1,000 row-feet or 6.7 - 13.3 lbs per acre	None		●			●				●	
permethrin Pounce 1.5G	Foliar applications: 5 - 10 lbs per acre	30 days		●			●	●				
permethrin Ambush *RUP*	Banded soil applications: 0.5 - 1 fl oz per 1,000 row-feet	None		●			●					
permethrin Ambush Ambush 25W *RUP*	Pre-emerge broadcast: 6.4 - 12.8 oz per acre 6.4 - 12.8 oz per acre 6.4 - 9.6 oz	30 days		●			●					
permethrin Arctic 3.2EC PermaStar AG Permethrin 3.2EC Perm-UP 3.2EC *RUP*	Soil applications: 0.3 - 0.6 fl oz per 1,000 row-feet or 4 - 6 fl oz per acre	30 days		●			●					
permethrin Ambush Ambush 25W Arctic 3.2EC PermaStar AG Permethrin 3.2EC Perm-Up 3.2 EC *RUP*	Foliar applications: 6.4 - 12.8 fl oz 6.4 - 12.8 oz 4 - 6 fl oz 4 - 8 fl oz 4 - 8 fl oz 4 - 6 fl oz 4 - 8 fl oz	30 days		●		●	●	●				
permethrin Kernel Guard Supreme	Planter Box: 1.5 oz per 42 lbs of seed	45 days for grazing or feeding									●	
phorate Thimet 20G Lock n Load Thimet 20G SmartBox *RUP*	4.5 - 6 oz per 1,000 row-feet	30 days			●					†	●	
spinosad (microbial) Blackhawk Entrust Tracer	1.67 - 3.3 oz 0.5 - 2 oz 1 - 3 fl oz	28 days for fodder 7 days for forage 1 day for grain		●				●				
spinetoram Radiant SC	3 - 6 fl oz	28 days for grain, 3 days for fodder and forage		●				●				
spiromesifen Oberon 2 SC	5.7 – 16.0 fl oz	5 days for green forage and silage 30 days for grain or stover										●
sulfoxaflor Transform WG	0.75 - 1.5	14 days for grain and straw 7 days for grazing, forage, fodder	●									
tefluthrin Force 3G Force 3G SmartBox Force 6.5G Force Evo Precept *RUP*	3G, 3G SmartBox: 4 - 5 oz per 1,000 row-feet 6.5G: 1.8 - 2.3 oz per 1,000 row feet Evo: 0.46 - 0.57 fl oz per 1,000 row-feet Precept: 4 - 5 oz per 1,000 row-feet	None			●		●			●	●	

Corn

INSECTICIDE	PRODUCT PER ACRE	PHI	Aphids	Armyworms	Corn Rootworm Larvae	Corn Rootworm Adults	Cutworms	European Corn Borer	Grasshoppers	White Grubs	Wireworms	Spider mites
terbufos Counter 15G SmartBox Counter 15G Lock n Load Counter 20G SmartBox Counter 20G Lock n Load *RUP*	6 - 8 oz per 1,000 row-feet 4.5 - 6 oz per 1,000 row-feet	30 days for grazing and forage			●		†			●	●	
thiamethoxam Cruiser 5FS	0.25 – 0.8 mg active ingredient per kernel (1 fl oz contains 17.7 g active ingredient)	None	●				●			●	●	
zeta-cypermethrin Mustang Maxx Mustang Maxx EC	At Plant: 0.16 fl oz per 1,000 row-feet	30 days for grain 60 days for forage					●					
zeta-cypermethrin Mustang Maxx *RUP*	1.28 - 4 fl oz	7 days for grain, stover and forage	●	●		●	●	●	●			

RUP = Restricted Use pesticide
● = Control
† = Suppression Only
‡ = Control of first and second instar larvae only

Corn

FLAX INSECTS

Other resources available through NDSU Extension Service:
Publications E830 The Armyworm and the Army Cutworm (revised 2018)

Flax may be infested from the time of emergence to maturity by various insect pests. Fields should be examined regularly and controls applied when infestations reach the economic threshold. The following species are potentially damaging but often occur in too low of numbers to cause economic loss.

ARMY CUTWORM

Larvae of the army cutworm, *Euxoa auxiliaris*, damage flax and many other crops by feeding on foliage in the spring. It can be an important pest in southwestern North Dakota. Populations of 9 per square yard can cause significant damage.

ASTER LEAFHOPPER

The aster leafhopper, *Macrosteles quadrilineatus*, can damage flax. This insect feeds by sucking juices from the flax plants. More importantly, aster leafhoppers can carry the Aster Yellows phytoplasm and the crinkle virus, and can infect the plants with these diseases while feeding. The damage from these insects is most serious on late-seeded crops.

BERTHA ARMYWORM

The bertha armyworm, *Mamestra configurata*, was a regular pest of flax before canola and mustard were grown on the prairies. However, since their widespread introduction, the bertha armyworm rarely causes economic damage to weed-free flax fields. If bertha armyworm-infested canola fields are swathed and green flax fields are nearby, the flax can suffer significant damage from invading larvae. When abundant, bertha armyworms cause serious damage by chewing through the stems below the bolls, causing them to drop to the ground. Young bertha larvae are green but larger larvae are usually velvet-black.

GRASSHOPPERS

Grasshoppers have been the **No. 1 threat to North Dakota flax**. Young grasshoppers may attack young plants and cause damage. However, more damage is done to the crop before harvest by the older, larger grasshoppers. They can quickly cause large numbers of bolls to drop by chewing through the more succulent portions of the stem below the bolls. Growers need to be aware of grasshopper activity in the vicinity of flax fields well before adult migration begins in July. Because of the limited availability of insecticides to control insects in flax, attempts to reduce grasshopper populations in neighboring crops and non-crop areas are advisable.

PALE WESTERN AND REDBACKED CUTWORMS

Two subterranean species of cutworms, the redbacked (*Euxoa ochrogaster*), and the pale western (*Agrotis orthogonia*), infest flax. The adult moths of these species lay eggs on the soil surface in weedy summer fallow fields during late summer. These eggs overwinter and the young larvae feed on flax seedlings in the spring. Cutworms usually remain below ground, cut off the young plants near the soil surface and draw them down where they are eaten. An average population of 10 cutworms per square yard can cause a 10% reduction in the yield of flax, and control should be considered.

WIREWORMS

Wireworms, although often serious pests of cereal grains in the seedling stage, seldom damage flax. Cruiser and Gaucho are labeled as commercial seed treatment for control of wireworm on flax and use decisions must be made at time of seed purchase. Please the seed treatment section in the introduction for more information.

INSECTICIDES REGISTERED FOR USE IN FLAX

INSECTICIDE	PRODUCT PER ACRE	PHI	Army Cutworm	Aster Leafhopper	Berth Armyworm	Other Cutworms	Grasshoppers	Wireworms
carbaryl Sevin 4F Sevin XLR Plus	1 - 1.5 qts 1 - 1.5 qts	42 days for seed and straw			●			
imidacloprid Dyna-Shield Imidacloprid 5 Gaucho 600F Senator 600FS	10.2 - 25.6 fl oz per cwt	None						●
thiamethoxam Cruiser 5FS	10.24 fl oz per cwt	None						●
zeta-cypermethrin Mustang Maxx *RUP*	4 fl oz	7 days	●		●	●	●	

RUP = Restricted Use Pesticide
● = Control

Flax

FORAGE INSECTS

Other Resources Available Through NDSU Extension Service:

Publications	E1676	Integrated Pest Management of Alfalfa Weevil in North Dakota (2018)
	E830	The Armyworm and the Army Cutworm (revised 2018)

ALFALFA BLOTCH LEAFMINER

Alfalfa acreage in the upper Midwest was recently invaded by the alfalfa blotch leafminer (ABL). ABL is a gnatlike fly (Diptera) from Europe that was first detected in North America, in Massachusetts, in 1968. By 1994, populations of ABL reached northern Minnesota and by 1997 could be found throughout Wisconsin, the northern 2/3 of Minnesota, and the northeastern corner of Illinois. By October 1998, ABL was distributed throughout Minnesota, Wisconsin, northern Illinois, and eastern North Dakota. Observations suggest that this insect may reduce alfalfa yields by 7% to 20% and protein content by 10% to 20%. Both adults and larvae damage the plant. Females feed by puncturing leaves with their ovipositors, creating characteristic "pinholes," and consuming plant juices. A single female creates an average of 3,769 pinholes during her lifetime. Larvae emerging from eggs create distinctive mines as they feed. Within a field, it is not uncommon for 70% or more of the leaflets to be attacked. The wounds also increase the susceptibility of alfalfa to diseases, especially spring black stem. Still unclear is the economic impact of damage caused by ABL, but the visible damage caused by even low numbers of flies can be disturbing. In the northeastern United States, populations have been supressed by parasitic wasps and control is not recommended.

Severe infestations appear one year after initial colonization by the leafminer. Infestations have spread to central North Dakota. The first generation in May-June causes the most visible damage. Infested fields take on a whitish cast due to the larval mines in the leaves. The same appearance can be confused with alfalfa weevil feeding; however, leafminers do not skeletonizing the leaves.

Thresholds: Treatment is suggested if 30% to 40% of the plants exhibit pinhole feeding injury. Though several insecticides are available for ABL control in alfalfa, insecticide efficacy trials in Minnesota have not demonstrated significant economic return. If insecticides are used, they must be applied during the "pinhole" stage.

ALFALFA WEEVIL

Historically, alfalfa weevil larvae are not a widespread concern in North Dakota, occurring mainly in the southern counties when they are a problem. The light green larvae have a white stripe down the center of the back. They feed in the terminal buds of the growing alfalfa. They may be found in rolled up leaves at the growing tip of the plant. Feeding injury appears as small, circular holes in leaves. As larvae increase in size, feeding injury is more evident. Severely damaged fields take on a silvery appearance due to defoliation.

Alfalfa Weevil Management: If alfalfa weevil infestations are observed, one of the best strategies is to cut fields for hay early. After cutting, monitor carefully for signs of damage or delayed regrowth, particularly in the swath area where larvae may be concentrated. When early cutting of the crop is not possible, treatment should be considered when 30% of the plants show feeding damage and larvae are still present. The second cutting should be scouted for feeding injury. Treat if 50% of the crowns have weevil feeding, and re-growth is delayed 3-6 days. Feeding injury is often concentrated underneath the windrows. To sample, inspect 20 stems from each of 5 sites in the field, recording the percent of damaged plants and whether larvae were found.

A more detailed **economic threshold for the number of alfalfa weevil larvae per stem** is shown in the Table 1, which is based on the plant growth stage (height), treatment cost and crop market value. See E1676 Integrated Pest Management of Alfalfa Weevil in North Dakota (2013) for more information.

Table 1. Recommended economic thresholds for third- and fourth-instar alfalfa weevil larvae for North Dakota prior to the first cutting.

Plant Growth Stage (Height)	Treatment Cost	Crop Value ($/ton)						Management Decision
		$50	$75	$100	$125	$150	$175	
50% bud or greater								Cut early
Early bud (>20 inches)	$7/acre	4.0	2.7	2.0	1.6	1.3	1.2	Cut early, or use a short PHI/PGI product
	$8/acre	4.6	3.1	2.3	1.8	1.5	1.3	
	$9/acre	5.2	3.5	2.6	2.1	1.7	1.5	
	$10/acre	5.8	3.8	2.9	2.3	1.9	1.6	
	$11/acre	6.3	4.2	3.2	2.5	2.1	1.8	
	$12/acre	6.9	4.6	3.5	2.8	2.3	2.0	
Late vegetative (16-20 inches)	$7/acre	3.8	2.4	1.8	1.4	1.1	0.9	Use a short to mid-PHI/PGI product
	$8/acre	4.4	2.8	2.1	1.6	1.3	1.1	
	$9/acre	4.9	3.2	2.4	1.8	1.5	1.2	
	$10/acre	5.5	3.6	2.6	2.1	1.7	1.4	
	$11/acre	6.1	4.0	2.9	2.3	1.9	1.6	
	$12/acre	6.7	4.4	3.2	2.5	2.1	1.7	
Mid-vegetative (10-15 inches)	$7/acre	3.6	2.2	1.5	1.1	0.9	0.7	Use a long-residual product
	$8/acre	4.1	2.6	1.8	1.4	1.1	0.8	
	$9/acre	4.7	3.0	2.1	1.6	1.2	1.0	
	$10/acre	5.3	3.4	2.4	1.8	1.4	1.2	
	$11/acre	5.9	3.7	2.7	2.1	1.6	1.3	
	$12/acre	6.4	4.1	3.0	2.3	1.8	1.5	

BLISTER BEETLES

Several blister beetle species feed on forage crops, including *Lytta nuttalli*, a large purplish green beetle; *Epicauta fabricii* or the ash-gray blister beetle; and *Epicauta ferruginea*, a smaller rusty-colored, pubescent beetle. Most blister beetle species have one generation per year. Adults become active in early to mid-summer and lay eggs in the soil. Eggs hatch in about two weeks into larvae called triungulins, which actively prey on grasshopper egg pods (*Epicauta* spp.) or bee nests (*Lytta* spp.). Blister beetles overwinter as larvae. Adult blister beetles are attracted to blooming alflafa fields, where they are ravenous feeders, devouring leaves, stems and flowers. Blister beetles are mobile and gregarious, and often congregate in certain spots in a field. In some instances, blister beetles feed for a short period of time and then migrate to other crops or fields.

Effects on Livestock: All species of blister beetles produce a toxic substance called cantharidin. This toxin is a well-known vesicant (blister-causing substance) that is quickly absorbed upon contact and causes infl ammation and blistering of internal and external body tissues. The amount of toxin produced varies considerably between species. Livestock come in contact with blister beetles when they consume infested alfalfa hay. Horses are most susceptible to the toxin, while sheep and cattle are more tolerant. The reaction to the toxin depends upon the relative dose; enough ingested beetles can be lethal to any animal. Symptoms of sublethal poisoning include depression, diarrhea, elevated temperatures, increased pulse and breathing rates, and dehydration. There is also frequent urination, especially after the first 24 hours. If cantharid poisoning is suspected, a veterinarian should be contacted immediately.

Management Strateiges: Several management options are available, which can reduce the number of blister beetles found in forage crops but none will eliminate the problem.

- Adjust harvest dates and maintain weed free alfalfa. Since blister beetles are readily attracted to flowering plants, controlling the number of flowering weeds in the field and cutting alfalfa prior to bloom stage will reduce the potential for infestation.
- Check hay for blister beetles prior to cutting. Blister beetles are gregarious and are often found in high numbers in localized areas of the field. Prior to harvest, growers should be aware of potential infestations, and if blister beetles are present in the field, the harvest should be delayed for several days. In many instances, the beetles will move. However, they may move to another part of the field, so a careful inspection is necessary
- If beetles are present in the field at the time of harvest, avoid using hay conditioners or crimpers. These implements may kill the beetles and prevent them from moving out of the hay as it dries. A self-propelled harvester which has wide-set wheels and no conditioner or crimping equipment can be used to windrow the hay, resulting in fewer dead blister beetles in the hay.
- Apply an insecticide for beetle control prior to harvest. Fields suspected of being infested should be thoroughly scouted (concentrating near the field edges) prior to harvest, and if blister beetles are present, an insecticide may be applied for control. Beetles killed by the insecticide will most likely fall to the ground and should not be picked up by the harvesting equipment. Fields should be rechecked 24 hours prior to cutting to ensure that new swarms of blister beetles have not reinfested the fields. Observe label directions for rates, pre-harvest intervals, restrictions and precautions. Fields should not be treated at peak bloom to avoid bee kill.
- In all cases, hay suspected of being infested with blister beetles should be checked for beetles prior to feeding. Contaminated hay should not be fed to horses or other livestock; removal of the beetles from the hay will not make it safe.
- It is to the grower's advantage to minimize harvest operations, which kill blister beetles, thereby minimizing the possibility of feed contamination. Management practices can only reduce the number of blister beetles present and the potential risk of cantharidin poisoning.

CUTWORMS

The variegated cutworm is an occasional pest of alfalfa and sweetclover in North Dakota. These larvae are about 2 inches long when full grown. Their color ranges from black to light greenish-yellow or tan. They have a distinctive row of pale yellow spots down the middle of their backs. Generally, the most serious damage from this cutworm would be on the stubble following the first cutting. Larvae may concentrate beneath windrows, causing severe damage to these areas.

Threshold: Treatments would be justified when more than 2 worms per square foot are present after the hay has been cut - if larvae are not expected to pupate in the next 3 to 4 days. Another management strategy is to delay cutting if larvae are close to full size and about to pupate. By delaying cutting, the feeding is distributed through the dense canopy of an established stand which is less detrimental than concentrated feeding on the young regrowth.

GRASSHOPPERS

In the Northern Plains, grasshopper egg hatch normally begins in late April to early May. Most grasshoppers emerge from eggs deposited in uncultivated ground or where plant cover attracted adults the previous season. Infestations could occur any time after emergence begins. Later infestations may develop when grasshopper adults migrate from harvested fields.

Thresholds: Threatening is considered the action threshold for grasshoppers. Since it is difficult to estimate the number of grasshoppers per square yard when population densities are high, pest managers can use four 180-degree sweeps with a 15-inch sweep net, which is equivalent to the number of adult (or nymph) grasshoppers per square yard.

	Nymphs per square yard		Adults per square yard	
Rating	Margin	Field	Margin	Field
Light	25-35	15-25	10-20	3-7
Threatening	50-75	30-45	21-40	8-14
Severe	100-150	60-90	41-80	15-28
Very Severe	200+	120+	80+	28+

LEAFHOPPERS

The potato leafhopper is wedge-shaped and pale green in color. It is only 1/8 inch long. Adults are very active, jumping or flying when disturbed. Both adults and nymphs will run backwards or sideways rapidly. Damage by leafhoppers is referred to as 'hopperburn.' Foliage becomes dwarfed, crinkled and curled. Small triangular brown areas appear at the tips of leaves, gradually spreading around the entire leaf margin. Both nymphs (immatures) and adults cause damage and should be counted when sampling with a sweep net. A minimum of 100 sweeps per field is recommended.

Thresholds: Suggested treatment guidelines are presented below. Thresholds are based on the number of nymph/adult leafhoppers per sweep when swinging a sweep net in a pendulum-like motion through the tops of the plants.

Stem Length (inches)	Average no. Leafhoppers/Sweep	Average no. Leafhoppers/100 Sweeps
3 or less	0.2	20
3-8	0.5	50
8 -12	1.0	100
12 - 14	2.0	200

LYGUS OR PLANT BUGS

Lygus bugs are a serious pest of alfalfa seed production. These insects are 1/4 inch long and range in color from pale green to light brown to reddish-brown. There is a light-colored, heart-shaped spot on the back. The nymphs are pale green and look similar to aphids, but are much more active movers. Lygus bugs feed on foliage, but the most serious feeding is on the flower buds, flowers, and developing seeds. Feeding injury causes blossoms to drop, and seeds to shrivel, turn brown and then fail to germinate.

Threshold: Treatments are justified when sweep net samples collect an average of 3 to 5 lygus bugs (adults and nymphs) per pendulum sweep. If insecticides are considered, attempt to time treatments for the control of nymphs prior to the onset of bloom. Protecting insect pollinators in seed production fields is very important.

PEA APHID

The pea aphid is light green and about 1/4 inch long. Alfalfa infested by pea aphids may appear wilted and have a bronze color. When present, pea aphids will crowd together on the terminal shoot, leaves or stems. Monitor fields closely during periods of slow plant growth.

Thresholds: Many aphids per plant are required before the vigor of that plant is reduced. Light populations may be beneficial by providing a food source for predatory and parasitic insects. On 10-inch tall alfalfa, treatment would not be needed until aphids exceed 50 per stem. Taller alfalfa will tolerate greater numbers.

INSECTICIDES REGISTERED FOR USE IN ALFALFA AND GRASS FORAGE CROPS

NOTE: When spraying legume fields, apply insecticides between 8 p.m. and 8 a.m. to protect the local bee population. Never spray fields in bloom.

INSECTICIDE	PRODUCT PER ACRE	PHI	Alfalfa Blotch Leafminer	Alfalfa Weevil	Blister Beetles	Cutworms	Grasshoppers	Leafhoppers	Lygus or Plant Bugs	Pea Aphid
alpha-cypermethrin **ALFALFA ONLY** Fastac CS Fastac EC *RUP*	2.2 - 3.8 fl oz	3 days cutting or grazing 7 days for seed		●	●	●	●	●	●	†
beta-cyfluthrin Baythroid XL *RUP*	0.8 - 2.8 fl oz	7 days for hay or grazing	●	●	●	●	●	●	●	†
carbaryl Sevin 4F Sevin XLR Plus	1 - 1.5 qts 1 - 1.5 qts	**Alfalfa:** 7 days for hay or grazing **Grasses:** 14 days for hay or grazing	●	●	●	●		●	●	
chlorantraniliprole Prevathon*	14 - 20 fl oz	None								
chlorantraniliprole + lambda-cyhalothrin Besiege *RUP*	Alfalfa: 5 - 9 fl oz Pasture, rangeland, hay: 5 - 10 fl oz	**Alfalfa:** 1 day for forage, 7 days for hay **Pasture and Rangeland:** 0 days **Grass grown for seed:** 7 days	●	●	●	●	●	●	●	●
chlorpyrifos **ALFALFA ONLY** Lorsban 15G	In-furrow or PPI at stand establishment: 6.7 lbs per acre	None				●				
chlorpyrifos **ALFALFA ONLY** Chlorpyrifos 4E AG Govern 4E Hatchet Lorsban 4E Lorsban Advanced Nufos 4E Vulcan Warhawk Whirlwind Yuma 4E *RUP*	0.5 - 2 pts	7 days for hay or grazing for 0.5 pt 14 days for 1 pt 21 days for > 1 pt	●	●		●	●	●	●	●
chlorpyrifos + lambda-cyhalothrin **ALFALFA ONLY** Cobalt Advanced *RUP*	6 - 38 fl oz	7 days for hay or grazing for 6-13 fl oz 14 days for 13-26 fl oz 21 days for > 26 fl oz	●	●	●	●	●	●	●	●
chlorpyrifos + zeta-cypermethrin **ALFALFA ONLY** Stallion *RUP*	2.5 - 11.75 fl oz	7 days for hay, grazing or seed		●	●	●	●	●	●	●

Forage

INSECTICIDE	PRODUCT PER ACRE	PHI	Alfalfa Blotch Leafminer	Alfalfa Weevil	Blister Beetles	Cutworms	Grasshoppers	Leafhoppers	Lygus or Plant Bugs	Pea Aphid
cyfluthrin Tombstone Tombstone Helios *RUP*	0.8 - 2.8 fl oz	7 days for hay or grazing	●	●	●	●	●	●	●	†
Diflubenzuron Dimilin 2L *RUP*	1 - 2 fl oz Target early instar nymphs	1 day before cutting					●			
dimethoate **ALFALFA ONLY** Dimate 4E Dimethoate 4E Dimethoate 4EC Dimethoate 400	0.5 - 1 pt	10 days for hay or grazing		†			●	●	●	●
flupyradifurone **ALFALFA AND CLOVER ONLY** Sivanto Prime	7 - 10.5 fl oz 14 fl oz (Lygus bugs)	Alfalfa: 7 days Clover: 14 days						●	†	●
gamma-cyhalothrin Declare *RUP*	0.77 - 1.54 fl oz	7 days for hay 1 day for grazing	●	●	●	●	●	●	●	●
indoxacarb Steward EC	4.6 - 11.3 fl oz	7 days		●				†		
lambda-cyhalothrin Grizzly Too Kendo Lambda-Cy Lambda-T LambdaStar Lamcap Nufarm Lambda Cyhalothrin 1EC Paradigm VC Province Silencer Silencer VXN Warrior II *RUP*	0.96 - 1.92 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 0.96 - 1.92 fl oz	**Alfalfa:** 7 days for hay, 1 day for grazing **Grasses:** 7 days for hay, 0 days for grazing	●	●	●	●	●	●	●	●
malathion Cheminova Malathion 57% Malathion 5 Malathion 57EC	1.5 - 2 pts 1.5 - 2 pts 1.5 - 2 pts	0 days		‡			●	●	●	●
malathion Fyfanon ULV AG	6 - 8 fl oz	0 days	●	‡			●	●	●	●
methomyl **ALFALFA ONLY** Lannate LV *RUP*	0.75 - 3 pts	7 days for hay or grazing	●	●		●			●	●
permethrin **ALFALFA ONLY** Ambush 25W Ambush Arctic 3.2EC PermaStar Permethrin 3.2EC Perm-Up 3.2EC *RUP*	3.2 - 12.8 oz 6.4 - 12.8 fl oz 4 - 8 fl oz 4 - 8 fl oz 4 - 8 fl oz 4 - 8 fl oz	14 days		●		●		●	●	●
phosmet Imidan 70W	1 - 1.33 lbs	7 days for hay and grazing		●			●	●		
sulfoxaflor **ALFALFA ONLY** Transform WG	0.75 - 2.75 oz	7 days for grazing, forage, fodder, or hay							●	●

INSECTICIDE	PRODUCT PER ACRE	PHI	Alfalfa Blotch Leafminer	Alfalfa Weevil	Blister Beetles	Cutworms	Grasshoppers	Leafhoppers	Lygus or Plant Bugs	Pea Aphid
zeta-cypermethrin Mustang Maxx *RUP*	2.24 - 4 fl oz	**Alfalfa:** 3 days for hay or grazing, 7 days for seed **Pasture and Rangeland:** 0 days for forage and hay, 7 days for straw and seed screenings		●	●	●	●	●	●	●

RUP = Restricted Use Pesticide
● = Control
† = Suppression only
‡ = Not effective against alfalfa weevil adults
* = Prevathon will control aboveground lepidopterous pests, such as alfalfa looper and armyworms

LUPINE INSECTS

Lupine has been grown as a grain legume. One of the primary insect pests of lupine in North Dakota has been blister beetles. Most species of blister beetles have one generation per year. Adults emerge from the soil throughout the growing season (May through September), though periods of peak activity vary with the species. Most species are more abundant in July and August. Common blister beetle species that feed on lupine are the ash gray and black blister beetles. The larvae of most blister beetle species infesting legumes prey on grasshopper egg pods. Therefore, large populations of blister beetles are frequently associated with grasshopper outbreaks. Consequently, legumes grown near rangeland have a greater likelihood of blister beetle infestation.

INSECTICIDES REGISTERED FOR USE IN LUPINE FOR BLISTER BEETLE CONTROL

NSECTICIDE	PRODUCT PER ACRE	PHI	Blister Beetles
alpha-cypermethrin Fastac CS Fastac EC *RUP*	**Foliar:** 1.3 - 3.8 fl oz	21 days	●
beta-cyfluthrin Baythroid XL *RUP*	2.4 - 3.2 fl oz	7 days Do not feed treated vines or hay to livestock	●
bifenthrin + zeta-cypermethrin Hero *RUP*	4.5 - 11.2 fl oz	21 days Do not graze or harvest vines for forage or hay	●
carbaryl Sevin 4F Sevin XLR Plus	0.5 - 1 qt	21 days for grain or hay 14 days for grazing or forage	●
chlorantraniliprole + lambda-cyhalothrin Besiege *RUP*	5 - 9 fl oz	21 days	●
cyfluthrin Tombstone Tombstone Helios *RUP*	2.4 - 3.2 fl oz 2.4 - 3.2 fl oz	7 days Do not feed treated vines or hay to livestock	
gamma-cyhalothrin Declare *RUP*	1.02 - 1.54 fl oz	21 days Do not graze or harvest vines for forage or hay	●
lambda-cyhalothrin Grizzly Too Kendo Lambda-Cy EC LambdaStar Lambda-T Lamcap Nufarm Lambda Cyhalothrin 1EC Paradigm VC Province Silencer Silencer VXN Warrior II *RUP*	1.28 - 1.92 fl oz 2.56 - 3.84 fl oz 2.56 - 3.84 fl oz 2.56 - 3.84 fl oz 2.56 - 3.84 fl oz 2.56 - 3.84 fl oz 2.56 - 3.84 fl oz 2.56 - 3.84 fl oz 2.56 - 3.84 fl oz 2.56 - 3.84 fl oz 2.56 - 3.84 fl oz 2.56 - 3.84 fl oz 1.28 - 1.92 fl oz	21 days Do not graze or harvest vines for forage or hay	●
zeta-cypermethrin Mustang Maxx *RUP*	2.72 - 4 fl oz	21 days Do not graze or harvest vines for forage or hay	●

RUP = Restricted Use Pesticide
● = Control

MUSTARD INSECTS

Other Resources Available Through NDSU Extension Service:
Publications E1234 Integrated Pest Management of Flea Beetles in Canola (2017)

Yellow mustard (*Sinapis alba*) is the most common type grown in North Dakota; small acreages of brown and Oriental (*Brassica juncea*) are also being grown. These mustards are grown for the seed and used as a condiment. Insects that affect canola may also affect mustard grown for seed. Fortunately, these insects have not caused serious problems for mustard seed on an annual basis.

FLEA BEETLES

Mustard grown for seed has generally not been at risk to significant flea beetle feeding injury. However, circumstances can develop that put mustard seedlings at greater risk. This crop has demonstrated greater tolerance to flea beetle feeding and is less attractive to the beetles when canola is available. However, if weather delays emergence (cold soils, mid-May snows, etc.) mustard plants may also be more vulnerable to flea beetle attack. Mustard plants may attract beetles in large numbers and put the crop at greater risk of stand loss. Once the crop advances beyond the seedling stage, serious damage usually does not occur, since vigorously growing mustard can outgrow the beetle defoliation. No major effects on plant vigor have been noted from the feeding of the larvae on plant roots. Insecticides are not generally available for use in mustard seed production. Insecticides for mustard greens are numerous, but are not permitted for use in mustard seed. Insecticides labeled for canola are not approved for use in mustard grown for seed. It is hoped that efforts underway to address insecticide availability for this crop will be successful.

WIREWORMS

Wireworms are most likely to be problems when mustard follows pasture or grassland. Infestations often are found in coarse textured soils (sandy loam) where moisture is abundant, perhaps in low spots of fields.

Thresholds: There is no easy way to estimate wireworm infestations. Two methods are currently used.

***Soil Sampling*:** Sample 20, well spaced, 1 square foot sites to a depth of 4 to 6 inches for every 40 acres being planted. If an average of 1 wireworm per square foot is found, treatment would be justified.

***Solar Baiting*:** In September, establish bait stations for 2 to 3 weeks before freeze. Place bait stations randomly through the field, but representing all areas of the field. There should be 10 - 12 stations per 40 acre field. Place one cup wheat and one cup shelled corn in a 4- to 6-inch deep hole. Cover grain with soil and then an 18-inch square piece of clear plastic. Dig up the grain. If an average of one or more wireworm larvae is found per station, treatment would be justified.

***Seed Treatment*:** Please the seed treatment section in the introduction for more information.

INSECTICIDES REGISTERED FOR USE IN MUSTARD

INSECTICIDE	PRODUCT PER ACRE	PHI	Flea Beetles	Wireworms
cyantraniliprole Lumiderm[1]	**COMMERCIAL SEED TREATMENT ONLY** 14.8 – 24.6 fl oz per cwt	None	●	
imidacloprid Attendant 600 Dyna-Shield Imidacloprid 5 Gaucho 600F Senator 600FS	10.24 - 25.6 fl oz per cwt	None	●	●
thiamethoxam Cruiser 5FS	10.24 fl oz per cwt	None	●	●
zeta-cypermethrin Mustang Maxx *RUP*	4 fl oz	7 days	●	

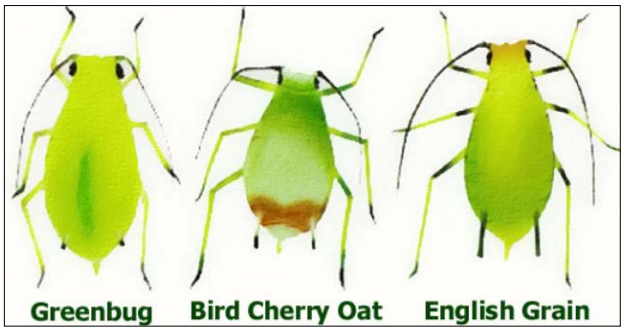
RUP = Restricted Use Pesticide
● = Control
[1] = Use higher rates of Lumiderm for flea beetle control (consult label for details)

OATS INSECTS

Other Resources Available Through NDSU Extension Service:

Publications	E1230	North Dakota Small-Grain Insects: Cereal Leaf Beetle (2016)
	E830	The Armyworm and the Army Cutworm (revised 2018)

APHIDS



Greenbug: pale green with darker stripe down back.
Bird Cherry Oat Aphid: olive green, brownish patch at the base of cornicles.
English Grain Aphid: bright green with long black cornicles.
The greenbug, English grain aphid and bird cherry oat aphids are the principal species that cause problems in North Dakota small grains. None of these aphids are known to overwinter in North Dakota; they migrate to the region from the South in late spring. The greenbug is the most injurious because it injects a toxin with its saliva during feeding. The English grain aphid is the most common aphid seen in small grains. Its population grows rapidly when feeding on wheat heads. The bird cherry oat aphid feeds primarily on leaves in the lower part of the small grain plant. These aphids transmit barley yellow dwarf virus. When aphid populations are high, the disease can spread through small grain fields. At greatest risk are later planted fields which attract migrating aphids that are moving from more mature fields.

Thresholds: English Grain, Bird Cherry Oat, Greenbug
To protect small grains from yield loss due to aphid feeding, the treatment threshold is 85% stems with more than one aphid present or 12-15 aphids per stem, prior to complete heading. Field scouting should begin at stem elongation and continue up to the heading stage of wheat. Aphid populations at or above the thresholds during these growth stages will result in economic injury to plants.
The greatest risk of yield loss from aphids feeding on grains is in the vegetative to boot stages. Significant yield reductions after the onset of flowering could not be demonstrated in research published from South Dakota in 1997 (Voss et al., 1997. J of Economic Entomology 90: 1346-1350). Reasons for these conclusions were that: after heading the only major yield component aphids can affect is seed weight; aphids are unable to sustain the very large populations necessary to achieve significant impact on this factor. Other components of yield are determined earlier (number of spikelets - determined at jointing; number of seeds - determined at flowering).

Russian Wheat Aphid (RWA):
15% to 20% of tillers infested up to flowering; 20+% infested tillers from flowering to early milk stage
Note: A tiller is infested whether it has one or several RWA present. RWA have only been found in southwest North Dakota during late summer; no economic damage has been reported. No RWA have been reported in North Dakota since the early '90s. Occasionally, RWA have overwintered during mild winters in Montana.

Natural Controls:
Lady beetles, aphid lions, syrphid fly, and parasitic wasps play a major role in reducing aphid populations. When natural enemies are present in large numbers, and the crop is well developed, farmers are discouraged from spraying fields.

ARMYWORMS

Armyworm outbreaks in North Dakota can occur when large migrations of moths from Southern states occur in late spring and early summer. Moths prefer to lay eggs in moist, shady areas where small grains or grasses have lodged or been damaged by hail or wind. Armyworms feed at night and hide under vegetation or in loose soil during the day. To scout for armyworms in grains, part the plants and inspect the soil for fecal pellets. If pellets or feeding damage is found, look for larvae under plant trash, soil clods or in soil cracks.

Threshold: Treat when 4 to 5 or more worms per square foot are present.
Migrating Armyworms: Treat a couple of swaths ahead of the infestation in the direction of movement to form a barrier strip.

CEREAL LEAF BEETLE

The cereal leaf beetle is an imported insect pest from Europe. This insect has been confirmed from **Burke, Cavalier, McKenzie, Nelson, Renville, Ward and Williams counties of North Dakota**. It was first detected in Michigan in 1962, Utah in 1984, and Montana in 1989. The cereal leaf beetle is a serious pest of barley and wheat in Montana. Both adults and larvae of the cereal leaf beetle damage grain crops through their foliar feeding. The larvae are the most damaging stage and the target of control measures. Generally, the newer plant tissue is preferred with feeding occurring on the upper leaf surface causing characteristic elongated slits.

Monitoring and Treatment Threshold: The first sign of CLB activity in the spring is adult feeding damage on the plant foliage. While this is the first sign of adult activity, adults are not the target of control. Eggs and larvae are monitored by plant inspection since thresholds are expressed as egg and larvae numbers per plant or per stem. Examine 10 plants per location and select 1 location for every 10 acres of field. Count number of eggs and larvae per plant (small plants) or per stem (larger plants) and get an average number of eggs and larvae, based on the samples you have taken. Boot stage is a critical point in plant development and impact of cereal leaf beetle feeding damage can be felt on both yield and grain quality.
Before boot stage, the threshold is 3 eggs and/or larvae or more per plant (including all the tillers present before the emergence of the flag leaf). Larvae feeding in early growth stages can have a general impact on plant vigor. When the flag leaf emerges, feeding is generally restricted to the flag leaf which can significantly impact grain yield and quality.

At the boot stage - 1 larvae or more per flag leaf.

CUTWORMS

Several cutworm species affect regional crops. In western North Dakota, the pale western and the army cutworms are important pests of small grains. Eggs of pale western hatch in the spring and larvae feed underground. Eggs of the army cutworm hatch in the fall and spring feeding is above ground. In eastern North Dakota, the Dingy cutworm, *Feltia jaculifera*, overwinters as a partially grown larva and is one of the first cutworm species to cause problems during crop emergence from early to mid-May. The moth of the dingy cutworm is known to lay her eggs on sunflower heads from mid-July through September. Crops following sunflowers in rotation are at greatest risk of injury by this cutworm. Other cutworms, the red-backed, *Exoa ochregaster*, and the darksided, *Exoa messoria*, overwinter as eggs which hatch in mid to late May. Eggs are laid in the fall and survive in weedy, wet, and reduced-tillage areas. Feeding injury by these cutworms normally occurs in late May to early June.

Thresholds: Treatment is recommended when cutworms number 4 to 5 per square foot.

GRASSHOPPERS

In the Northern Plains, grasshopper egg hatch normally begins in late April to early May. Peak hatch occurs about mid-June. Heavy infestations typically occur in areas of low rainfall or during drought years. Outbreaks are usually preceded by several years of hot, dry summers and warm falls. Cool, wet weather increases disease occurrence and delays development of grasshoppers, reducing the overall population.

Cultural Control Methods:

Early seeding: Allows for early establishment and vigorous growth of plants.

Crop rotation: Avoid planting in areas of high egg deposits. Fields with late-maturing crops or green plant cover attract adults which then lay eggs.

Tillage: Summer fallow will act as a trap crop, attracting females for egg laying. Spring tillage of these sites will reduce successful emergence of nymphs.

Thresholds: The threatening rating is considered the action threshold for grasshoppers. Since it is difficult to estimate the number of grasshoppers per square yard when population densities are high, pest managers can use four 180-degree sweeps with a 15-inch sweep net, which is equivalent to the number of adult (or nymph) grasshoppers per square yard.

	Nymphs per square yard		**Adults per square yard**	
Rating	Margin	Field	Margin	Field
Light	25-35	15-25	10-20	3-7
Threatening	50-75	30-45	21-40	8-14
Severe	100-150	60-90	41-80	15-28
Very Severe	200+	120+	80+	28+

WIREWORMS

Wireworms are most likely to be problems when crops follow pasture or grassland. Infestations often are found in coarse textured soils (sandy loam) where moisture is abundant, perhaps in low spots of fields.

Thresholds: There is no easy way to estimate wireworm infestations. Two methods are currently used.

***Soil Sampling*:** Sample 20, well spaced, 1 square foot sites to a depth of 4 to 6 inches for every 40 acres being planted. If an average of 1 wireworm per square foot is found, treatment would be justified.

***Solar Baiting*:** In September, establish bait stations for 2 to 3 weeks before freeze. Place bait stations randomly through the field, but representing all areas of the field. There should be 10 - 12 stations per 40 acre field. Place one cup wheat and one cup shelled corn in a 4- to 6-inch deep hole. Cover grain with soil and then an 18-inch square piece of clear plastic. Dig up the grain. If an average of one or more wireworm larvae is found per station, treatment would be justified.

INSECTICIDES REGISTERED FOR USE IN OATS

INSECTICIDE	PRODUCT PER ACRE	PHI	Aphids	Armyworms	Cereal Leaf Beetle	Cutworms	Grasshoppers	Wirworms
Bacillus thuringiensis Biobit HP Dipel DF Dipel ES	 0.5 - 2 lbs 1 - 2 lbs 2 - 4 pts	None		‡				
beta-cyfluthrin Baythroid XL *RUP*	1 - 2.4 fl oz	30 days for grain 3 days for grazing or forage	●	‡	●	●	●	
chlorantraniliprole Prevathon	14 - 20 fl oz	14 days		●				
chlorantraniliprole + lambda-cyhalothrin Besiege *RUP*	5 - 10 fl oz	30 days	●	●	●	●	●	
clothianidin Intego SUITE Cereals OF[1] NipsIt SUITE Cereals OF[1] NipsIt Inside Insecticide[1]	5.2 fl oz per cwt 5 - 7.5 fl oz per cwt 0.25 - 1.79 fl oz per cwt	**REI:** 24 hrs	*				*	●
diflubenzuron Dimilin 2L **FOR USE WEST OF US HIGHWAY 281 ONLY** *RUP*	1 - 4 fl oz	50 days for grain or straw 15 days for hay 3 days for forage			‡		‡	
flupyradifurone Sivanto Prime	7 - 10.5 fl oz	7 days for forage 21 days grain, stover and straw	●					
imidacloprid Attendant 480FS	0.16 - 0.32 fl oz per cwt	45 days for grazing or forage						†
imidacloprid Attendant 480FS Attendant 600 Dyna-Shield Imidacloprid 5 Gaucho 600 Senator 600FS	 1 - 3 fl oz per cwt 0.8 - 2.4 fl oz per cwt 0.8 - 2.4 fl oz per cwt 0.8 - 2.4 fl oz per cwt 0.8 - 2.4 fl oz per cwt	45 days for grazing or forage	*				*	●
imidacloprid Enhance AW	4 oz per cwt	45 days for grazing or forage	*					
imidacloprid Rancona Crest Rancona Crest WR Warden Cereals HR Warden Cereals WR	5 - 8.33 fl oz per cwt	45 days for grazing or forage	*					
lambda-cyhalothrin Grizzly Too Kendo Lambda-Cy EC LambdaStar Lambda-T Lamcap Nufarm Lambda Cyhalothrin 1EC Paradigm VC Province Silencer Silencer VXN Warrior II *RUP*	 0.96 - 1.92 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 0.96 - 1.92 fl oz	30 days for grain or straw 7 days for grazing or forage	●	●	●	●	●	

Oats

INSECTICIDE	PRODUCT PER ACRE	PHI	Aphids	Armyworms	Cereal Leaf Beetle	Cutworms	Grasshoppers	Wirworms
malathion Cheminova Malathion 57% Malathion 5 Malathion 57EC	1.5 pts 1 - 2 pts 1.5 - 1.6 pts	7 days	●	●	●		‡	
malathion Fyfanon ULV AG	4 - 8 fl oz	7 days			●		●	
spinetoram Radiant SC	2 - 6 fl oz	21 days for grain or straw 3 days for forage, fodder or hay		●	●		†	
spinosad Blackhawk Entrust Spintor 2SC Tracer	1.1 - 3.3 oz 0.5 - 2 oz 2 - 6 fl oz 1 - 3 fl oz	21 days for grain or straw 3 days for forage, fodder or hay		●	●		†	
sulfoxaflor Transform WG	0.75 - 1.5 oz	14 days for grain and straw 7 days for grazing, forage, fodder or hay	●					
thiamethoxam Cruiser Maxx Vibrance Cereals	5 - 10 fl oz	Do not graze or feed livestock on treated areas for 45 days						●
thiamethoxam Warden Cereals 360[3] Warden Cereals WR II[3]	5 fl oz per cwt	Warden Cereals WR II: Do not graze or feed livestock on treated areas for 45 days	*					●

RUP = Restricted Use Pesticide
● = Control
* = Seed treatments may not provide early-season aphid and grasshopper control
† = Suppression only
‡ = Control of first and second instar larvae or nymphs only
[1] For protection against early season aphids, grasshoppers or heavy wireworms pressure, add 1.4 to 1.5 fl oz per cwt of NipsIt INSIDE Insecticide to NipsIt SUITE Cereals OF or Intego SUITE Cereals OF; consult each label for registered use rates and follow all label instructions.
[2] = For aphid and wireworm control, add up to 0.8 fl oz per cwt of Cruiser 5FS.

POTATO INSECTS

Other resources available through NDSU Extension Service:
Publications: Management of Potato Psyllids (2016) https://www.ag.ndsu.edu/extensionentomology/field-crops-insect-pests/potato

APHIDS

Aphids are major pests of seed potatoes because they transmit viruses which lead to rejection of the seed lot. For this reason, seed producers must keep aphid numbers lower than what can be tolerated on table stock. The most common aphid found on potato is the green peach aphid, an important vector of potato leaf roll virus (PLRV). Many aphids can transmit potato virus Y (PVY). Control measures are targeted specifically against aphids to keep virus spread to a minimum in seed production; control is not as common in normal commercial production.

Thresholds

***Seed Stock*:** To prevent the spread of PLRV, treat when aphid populations reach levels of 10 aphids per 100 leaves. Insecticides will not effectively prevent the spread of PVY.

***Table Stock*:** To prevent a yield loss from direct feeding by aphids, treat when aphid densities reach 30 aphids per 100 leaves. Sample only middle to lower leaves; aphids will rarely be found on young leaves.

CABBAGE LOOPER

Many different defoliating insects can be found on potatoes. Potatoes are relatively tolerant of some defoliation, especially if the attack is not sustained. The cabbage looper is a light green caterpillar with white or pale yellow stripes down the side. They have only three pair of fleshy prolegs, causing them to loop when moving forward.

Threshold: Normal populations seldom reach economically significant levels in North Dakota.

COLORADO POTATO BEETLE

This beetle is the most common and destructive leaf feeding pest of potato. Both adults and larvae feed on foliage. The adult is 3/8 inch long, with oval body and a yellow-brown color with 5 black stripes on each wing cover. The larvae are 1/8 to 3/8 inch long, brick red to light orange in color. Eggs are laid on the underside of leaves in clusters of 10 to 30 and are orange colored when ready to hatch. In North Dakota, overwintered beetles emerge from May to June. The first-generation larvae are present in the fields from June through July. Beetles from these larvae appear in fields in July, feeding and laying eggs for a second generation. One of the greatest concerns with management programs for beetles is resistance to insecticides. The best way to manage the development of resistance in an insect population is the reduced use of compounds, limiting the selection of surviving (resistant) individuals. In North Dakota, resistance to the pyrethroid insecticides has been documented and the use of these compounds should be limited to one application per season. If control failures occur following the application of any product, switching to a different class of insecticides is recommended.

Threshold: The current recommendation is that spraying be initiated at first egg hatch. Best results have been achieved by flagging the first egg masses that can be located, monitoring these daily, and spraying at 15 to 30% hatch. If the insecticide used is effective but not persistent, a second application should be made 5 to 10 days later. With this approach, the first-generation beetle larvae should be controlled with one or two applications.

FLEA BEETLE

Flea beetles are small, dull black beetles, about 1/16 inch long, with hind legs adapted for jumping. The adults overwinter in the soil, emerging in the spring to begin feeding on young foliage. Newly emerged plants are most vulnerable. When abundant, flea beetles shot-hole the foliage with numerous small round holes. Severely damaged leaves do not recover.

Threshold: Thresholds for this pest are not well-defined. Past recommendations have suggested treatment when 10% of the leaf area is lost due to flea beetle feeding. Early season weed control and removal of crop debris make fields less attractive to flea beetles.

POTATO LEAFHOPPER

Direct feeding damage to foliage is the primary concern with leafhoppers. The potato leafhopper migrates north in the spring, arriving before potatoes emerge. Leafhoppers develop in alfalfa first, moving to potatoes later.

Leafhopper adults are wedge-shaped, 1/8 inch long, and lime green to yellow green in color. The nymphs resemble the adults but are wingless. When disturbed, the nymphs move across the leaf in a sideways fashion.

Damage by leafhoppers is referred to as hopper-burn. Foliage becomes dwarfed, crinkled, and curled. Small triangular brown areas appear at the tips of leaves, gradually spreading around the entire leaf margin. Immature leafhoppers are more destructive than the adults, and generally more numerous than adults.

Threshold: Sample 35 leaves in each of 5 locations in a field. Pluck leaves from the plants and inspect the underside of the leaf for the presence of nymphs. Treatments are recommended when potato leafhoppers (PLH) can be found at:

Seedling Stage (two true leaves)
Adults: 0.5 adult PLH per sweep or 2 per row foot
Nymphs: Nymphs PLH usually not present at seedling stage
3rd Trifoliate to Bud Stage

Adults: 1-2 adult PLH per sweep or 5 PLH per row foot
Nymphs: 1 nymph PLH per 10 leaflets

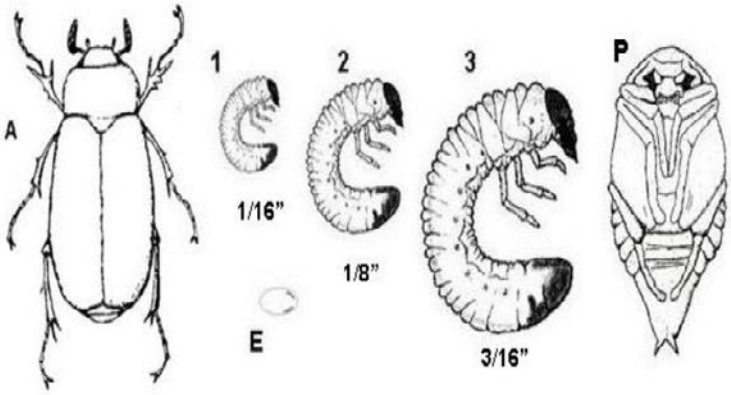
VARIEGATED CUTWORM

The variegated cutworm is an occasional pest of potato in the region. These larvae are about 2 inches long when full grown. Their color ranges from black to light greenish-yellow or tan. They have a distinctive row of pale yellow spots down the middle of their backs. The variegated cutworm is a climbing cutworm, feeding in the plant canopy at night. Variegated cutworm have been responsible for below-ground feeding that damages tubers. The variegated cutworm overwinters in states to the south of North Dakota, making annual predictions of problems difficult. Moths migrate to the region during the spring and summer months. There are multiple generations of this cutworm, numbering two to three, depending on environmental conditions.

Threshold: Treatments would be justified when 4 or more worms per square foot are present.

WHITE GRUBS

White grubs that are destructive to field crops in North Dakota have a three-year life cycle. In southeast North Dakota, the most common white grub pest occurs in continuous cropping situations at sites where willow and cottonwood trees are present. In other areas of the state, white grubs are most likely to be found when rotation from grassland, pasture, or grassy weed sites occur. Most root feeding occurs in the second year of the life cycle. In most cases, the number of second-year grubs will only be great enough to justify control once every three years.



Life stages of Phyllophaga implicita: A - adult June beetle; E - egg; grub stages with their head width in inches, 1 - first; 2 - second; 3 - third; and P - pupa.

Thresholds: Treatment is recommended when sampling indicates an average of one or more white grubs per square foot are found. The following sampling procedure provides treatment decisions based on this guideline.

***Soil sampling*:** Fields need to be sampled to determine grub abundance and aid in determining if control is necessary. Sampling in late summer or early fall, before a freeze, provides a more reliable estimate of populations than spring sampling just before planting. Larvae are typically present in the upper 6 inches of soil until a killing frost occurs in the fall. Take soil samples, 1 square foot in size to a depth of 8 inches. Begin taking samples 45 yards from shelterbelts. A total of 30 samples per field, randomly spaced along the shelterbelts, are necessary. If at least a single grub is found in less than 40% of the samples, treatment may be required only out 20 yards from the tree line. If 40% to 60% of the samples are infested, treatment is needed to this distance and maybe as far as 65 yards. If greater than 60% of the samples are infested, treatment may be needed out to 90 yards from the tree line.

WIREWORMS

Wireworms are most likely to be problems when crops follow pasture or grassland. Infestations often are found in coarse textured soils (sandy loam) where moisture is abundant, perhaps in low spots of fields.

Thresholds: There is no easy way to estimate wireworm infestations. Two methods are currently used.

***Soil Sampling*:** Sample 20, well spaced, 1 square foot sites to a depth of 4 to 6 inches for every 40 acres being planted. If an average of 1 wireworm per square foot is found, treatment would be justified.

***Solar Baiting*:** In September, establish bait stations for 2 to 3 weeks before freeze. Place bait stations randomly through the field, but representing all areas of the field. There should be 10 - 12 stations per 40 acre field. Place one cup wheat and one cup shelled corn in a 4- to 6-inch deep hole. Cover grain with soil and then an 18-inch square piece of clear plastic. Dig up the grain. If an average of one or more wireworm larvae is found per station, treatment would be justified.

INSECTICIDES REGISTERED FOR USE IN POTATO

INSECTICIDE	PRODUCT PER ACRE	PHI	Aphids	Cabbage Looper	Colorado Potato Beetle	Flea Beetles	Potato Leafhopper	Potato Psyllid	Variegated Cutworm	White Grubs	Wireworms
abamectin ABBA 0.15EC Agri-Mek 0.15EC Epi-Mek 0.15EC Nufarm Abamectin 0.15EC Reaper 0.15EC Timectin 0.15EC *RUP*	8 - 16 fl oz	14 days Do not allow livestock to graze or feed treated foliage to livestock			●			●			
abamectin Agri-Mek SC *RUP*	1.75 - 3.5 fl oz	14 days			●			●			
acetamiprid Assail 30SG	1.5 - 4 oz	7 days	●		●	●	●				
afidopyropen Sefina	3 fl oz	7 days	●								
alpha-cypermethrin Fastac CS Fastac EC *RUP*	1.3 - 3.8 fl oz	1 day Do not use leaves or vines for food or feed	†	●	●	●	●		●		
avermectin + bifenthrin Athena *RUP*	7 - 17 fl oz	21 days	●	●	●	●	●	●	●		
Bacillus thuringiensis Biobit HP Dipel DF Dipel ES Xentari DF	0.5 - 1 lb 0.5 - 1 lb 1 - 2 pts 0.5 - 1.5 lbs	None		‡					‡		
beta-cyfluthrin Baythroid XL *RUP*	0.8 - 2.8 fl oz	None for tubers 14 days for grazing if more than 5.6 fl oz per acre is applied	†	●	●	●	●	●	●		
beta-cyfluthrin + imidacloprid Leverage 360 *RUP*	2.8 fl oz	7 days	●	●	●	●	●	●	●		
bifenthrin Bifen 2 AG Gold Bifenture EC Brigade 2EC Fanfare 2EC Sniper Sniper Helios Tundra EC *RUP*	At Plant, In-furrow or T-band: 19.2 fl oz Lay-by: 3.2 - 9.6fl oz	21 days								●	●
bifenthrin Bifender FC Bifen 2 AG Gold Bifenture EC Brigade 2EC Fanfare 2EC Sniper Sniper Helios Tundra EC *RUP*	Foliar Application: 2.4 - 7.4 fl oz 2.1 - 6.4 fl oz 2.1 - 6.4 fl oz 2.1 - 6.4 fl oz 2.1 - 6.4 fl oz 2.1 - 6.4 fl oz 2.1 - 6.4 fl oz 2.1 - 6.4 fl oz	21 days				●					
bifenthrin Bifender FC *RUP*	At Plant In-furrow, T-band or Lay-by: 11 - 22.1 fl oz	None listed								●	●

Potato

INSECTICIDE	PRODUCT PER ACRE	PHI	Aphids	Cabbage Looper	Colorado Potato Beetle	Flea Beetles	Potato Leafhopper	Potato Psyllid	Variegated Cutworm	White Grubs	Wireworms
bifenthrin Capture LFR Ethos XB Sniper LFR *RUP*	At Plant In-furrow, T-band or Lay-by: 12.75 - 25.5 fl oz	None listed								●	●
bifenthrin + imidacloprid Brigadier Skyraider Swagger *RUP*	At Plant: 16 - 25.6 fl oz 19.2 fl oz 32 - 51.2 fl oz	21 days	●		●	●	●	●		●	●
bifenthrin + imidacloprid Brigadier Skyraider Swagger *RUP*	Foliar Application: 3.8 - 6.14 fl oz 2.1 - 6 fl oz 7.6 - 12.28 fl oz	21 days	●	●	●	●	●	●			
bifenthrin + zeta-cypermethrin Hero *RUP*	2.6 - 10.3 fl oz	21 days	●	●	●	●	●		●		
carbaryl Sevin 4F Sevin XLR Plus	0.5 - 2 qts 0.5 - 2 qts	7 days			●	●	●		●		
chlorantraniliprole Coragen	3.5 - 5 fl oz	14 days		●	●						
chlorantraniliprole + lambda-cyhalothrin Besiege *RUP*	5 - 9 fl oz	14 days	●	●	●	●	●	●	●		
chlorantraniliprole + thiamethoxam Voliam Flexi	4 oz	14 days	●	●	●	●	●				
clothianidin Belay	In-furrow or Side-dress Application: 9 - 12 fl oz	None	●		●	●	●	†		●	●
clothianidin Belay	Foliar Application: 2 - 3 fl oz	14 days	●		●	●	●	†			
cyantraniliprole Exirel	5 - 20.5	7 days	†	●	●	†		●	●		
cyantraniliprole + abamectin Minecto Pro *RUP*	5.5 - 10 fl oz	14 days Do not feed or graze livestock on treated vines	●		●			●			
cyfluthrin Tombstone Tombstone Helios *RUP*	0.8 - 2.8 fl oz 0.8 - 2.8 fl oz	0 days for tubers 14 days for grazing	†	●	●	●	●	●	●		
deltamethrin Delta Gold *RUP*	1 - 2.4 fl oz	3 days Do not graze livestock on vines	†	●	●	●	●		●		
dimethoate Dimate 4E Dimethoate 4E Dimethoate 4EC Dimethoate 400	0.5 - 1 pt	0 days 0 days 2 days 0 days 0 days	●				●				

Potato

INSECTICIDE	PRODUCT PER ACRE	PHI	Aphids	Cabbage Looper	Colorado Potato Beetle	Flea Beetles	Potato Leafhopper	Potato Psyllid	Variegated Cutworm	White Grubs	Wireworms
dinotefuran Scorpion 35SL	Soil Application: 11 - 13 fl oz Foliar Application: 2 - 2.75 fl oz	7 days	†		●	●	●	●			
dinotefuran Venom	Soil Application: 6.5 - 7.5 oz Foliar Application: 1 - 1.5 oz	14 days	†		●	●	●	●			
esfenvalerate Asana XL *RUP*	2.9 - 9.6 fl oz	7 days	●	●	●	●	●	●	●		
fipronil Regent 4SC *RUP*	At Plant In-furrow: 0.184 - 0.22 fl oz per 1,000 row-feet depending on row spacing	90 days									●
flonicamid Beleaf 50G	2 - 2.8 oz	7 days	●								
flupyradifurone Sivanto Prime	7 - 14 fl oz	7 days	●		●		●	●			
imidacloprid Pasada 1.6F Prey 1.6 Sherpa	Foliar Application: 3.8 fl oz	7 days	●		●	●	●	●			
imidacloprid ADAMA Alias 2F AmTide Imidacloprid 2F Malice 2F Montana 2F Nuprid 2SC Widow	In-furrow, Side-dress or Banded Application: 0.9 - 1.3 fl oz per 1,000 row-feet	None	●		●	●	●	●			●
imidacloprid ADAMA Alias 2F AmTide Imidacloprid 2F Malice 2F Montana 2F Nuprid 2SC Widow	Seed Piece Treatment: 0.4 - 0.8 fl oz per cwt	None	●		●	●	●	●			●
imidacloprid AmTide Imidacloprid 2F Montana 2F Nuprid 2SC	Foliar Application: 3 fl oz	7 days	●		●	●	●	●			
imidacloprid ADAMA Alias 4F Advise Four Montana 4F Nuprid 4F Max Wrangler	In-furrow, Side-dress or Banded Application: 0.45 - 0.65 fl oz per 1,000 row-feet	None	●		●	●	●	●			●
imidacloprid ADAMA Alias 4F Advise Four Montana 4F Nuprid 4F Max Wrangler	Seed Piece Treatment: 0.2 - 0.4 fl oz per cwt	None	●		●	●	●	●			●

Potato

INSECTICIDE	PRODUCT PER ACRE	PHI	Aphids	Cabbage Looper	Colorado Potato Beetle	Flea Beetles	Potato Leafhopper	Potato Psyllid	Variegated Cutworm	White Grubs	Wireworms
imidacloprid ADAMA Alias 4F Advise Four Montana 4F Nuprid 4F Max	Foliar Application: 1.5 fl oz	7 days	●		●	●	●	●			
imidacloprid Admire Pro Nuprid 4.6F Pro	In-furrow, Side-dress or Banded Application: 5.7 - 8.7 fl oz per acre	None	●		●	●	●	●			●
imidacloprid Admire Pro Nuprid 4.6F Pro	Seed Piece Treatment: 0.17 - 0.35 fl oz per cwt	None	●		●	●	●	●			●
imidacloprid Admire Pro	Foliar Application: 1.3 fl oz	None	●		●	●	●	●			
imidacloprid Malice 75WSP	1 oz	7 days	●		●	●	●	●			
indoxacarb Avaunt	2.5 - 6 oz	7 days		●	●						
lambda-cyhalothrin Grizzly Too Kendo Lambda-Cy EC LambdaStar Lambda-T Lamcap Nufarm Lambda Cyhalothrin 1EC Paradigm VC Province Silencer Silencer VXN Warrior II *RUP*	0.96 - 1.92 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 0.96 - 1.92 fl oz	7 days	●	●	●	●	●	●	●		
lambda-cyhalothrin + thiamethoxam Endigo ZC *RUP*	3.5 - 4.5 fl oz	14 days	●	●	●	●	●	●	●		
malathion Cheminova Malathion 57% Malathion 5 Malathion 57EC	1.5 - 2 pts 1 pt 1 - 1.5 pts	None	●				●				
methomyl Lannate LV *RUP*	1.5 - 3 pts	6 days	●	●		●	●		●		
novaluron Rimon 0.83EC	6 - 12 fl oz	14 days		●	●						
oxamyl Vydate C-LV *RUP*	8.5 - 34 fl oz	7 days	●		●	●	●				
oxamyl Vydate L *RUP*	In-furrow: 1 - 2 gal Foliar Application: 1 - 4 pts	7 days	●		●	●	●				

Potato

INSECTICIDE	PRODUCT PER ACRE	PHI	Aphids	Cabbage Looper	Colorado Potato Beetle	Flea Beetles	Potato Leafhopper	Potato Psyllid	Variegated Cutworm	White Grubs	Wireworms
permethrin Ambush 25W Ambush Arctic 3.2EC PermaStar Permethrin 3.2EC Perm-UP 3.2EC *RUP*	3.2 - 12.8 oz 3.2 - 12.8 fl oz 4 - 8 fl oz 4 - 8 fl oz 4 - 8 fl oz 4 - 8 fl oz	14 days	●	●	●	●	●	●	●		
phorate Thimet 20G SmartBox Thimet 20G Lock n Load *RUP*	At Plant for Light or Sandy Soils: 8.5 - 11.3 oz per 1,000 row-feet At Plant for Heavy or Clay Soils: 13 - 17.3 oz per 1,000 row-feet	90 days	●		●	†	●	●			●
phosmet Imidan 70W	1.33 lbs	7 days			●	●	●				
pymetrozine Fulfill	2.75 - 5.5 oz	14 days	●					†			
spinetoram Radiant SC	4.5 - 8 fl oz	7 days		●	●						
spinosad Blackhawk Entrust Spintor 2SC Success Optim	1.7 - 3.5 oz 1 - 3 oz 3.2 - 9.6 fl oz 1.7 - 3.3 fl oz	7 days		●	●						
spiromesifen Oberon 2SC	8 - 16 fl oz	7 days						●			
spirotetramat Movento Movento HL	4 - 5 fl oz 2 - 2.5 fl oz	7 days	●					●			§
sulfoxaflor Transform WG	0.75 - 2.25 oz	7 days	●				●	●			
thiamethoxam Actara	1.5 - 3 fl oz	14 days	●		●	●	●				
thiamethoxam Cruiser 5FS	Seed Piece Treatment: 0.11 - 0.16 fl oz per cwt **Consult label for correct rate based on seeding rate**	None	●		●	●	●	●			●
thiamethoxam Cruiser Maxx Potato	Seed Piece Treatment: 0.19 - 0.27 fl oz per cwt **Consult label for correct rate based on seeding rate**	None	●		●	●	●	●			
thiamethoxam Cruiser Maxx Vibrance Potato	0.5 fl oz per cwt	None	●		●	●	●	●			
thiamethoxam Platinum Platinum 75SG	Soil Applications: 5 - 8 fl oz 1.66 - 2.67 fl oz **Consult label for soil application methods**	None	●		●	●	●	●			●
tolfenpyrad Torac	14 - 21 fl oz	14 days	●		●			●			

Potato

INSECTICIDE	PRODUCT PER ACRE	PHI	Aphids	Cabbage Looper	Colorado Potato Beetle	Flea Beetles	Potato Leafhopper	Potato Psyllid	Variegated Cutworm	White Grubs	Wireworms
zeta-cypermethrin Mustang Maxx *RUP*	1.28 - 4 fl oz	1 day Do not use leaves or vines for food or feed	†	●	●	●	●		●		

RUP = Restricted Use Pesticide
● = Control
† = Suppression only
‡ = Control of first and second instar larvae only
§= Wireworm suppression only

Potato

PULSE CROPS
CHICKPEA, DRY PEA AND LENTIL INSECTS

Other Resources Available Through NDSU Extension Service:

Publications:	A1166	Field Pea Production (2016)
	A1922	Pulse Crop Production Field Guide for North Dakota (2019)
	PP1704	Pea Seed-borne Mosaic Virus (PSbMV) in Field Peas and Lentils (2014)
	A1636	Growing Lentil in North Dakota (2013)
	E830	The Armyworm and the Army Cutworm (revised 2018)
	A1236	Growing Chickpea in North Dakota (revised 2018)
	E1877	Pulse Crop Insect Diagnostic Series Field Pea, Lentil and Chickpea (2018)
	E1879	Integrated Pest Management of Pea Leaf Weevil in North Dakota (2018)

NDSU Pulse-info website: http://www.ndsu.edu/pubweb/pulse-info/index.html

CUTWORMS

There are several species of cutworms that cause problems to agricultural crops in the northern Great Plains, such as dingy cutworm, red-backed cutworm, and pale western cutworm. Adult cutworms are a moth, and have dark wing colors (brown to gray) with markings, and about 1½ inch long wing length. A mature cutworm larva is about 1½ inches long and the size of a pencil in width.

Life cycle: Cutworms have one generation per year. They overwinter as eggs or young larvae depending on the species. Eggs hatch in April or early May, and young larvae (or caterpillars) feed at night on weeds and volunteer plants before the pulse crop emerges. Larvae molt six times and grow larger with each instar. Cutworms are most noticeable in crops from late May through late June. After cutworms complete their development in late June, they burrow deeper into the soil and make a small pupal chamber. Adult moths emerge from August through early September. Adults mate, and females lay eggs on or just below the surface of loose, dry soil, or weedy stubble, or fallow fields depending on the species.

Damage: Cutworm damage first appears on hilltops, south facing slopes, or in areas of light soil, which warm up earlier in the spring. Larvae will cut young plants in the seedling to 6-8 leaf stages. Cut plants can be found drying up and lying on the soil surface. The shoots may be cut off below the soil surface. Cotyledons (seeds) of lentil often remain below the soil surface and can recover from cutworm damage if cool, moist growing conditions. However, recovered plants are generally set back 4 to 7 days by the damage. As damage continues, fields will have areas of bare soil where plants have disappeared. In a severe infestation, the entire field can be destroyed.

Pest Management: Scout fields by looking for freshly damaged (cut off) plants. Dig down three or more inches around the cut-off plant and search for cutworm larvae. When disturbed, cutworms curl up or hide under soil debris. Pulse crops are more susceptible to cutworm damage than small grains, because cut plants do not grow back (grains compensate by tillering). Cutworm larvae are actively feeding at night, so an evening insecticide application is best. As a cultural control technique, weed-free fields and crusted summer fallow fields are less attractive to egg laying adults in late summer.

Thresholds in Chickpea, Dry Pea and Lentil: Two to three cutworms per square yard justifies an insecticide treatment.

GRASSHOPPERS

The grasshopper is an insect in the order Orthoptera. There are numerous grasshopper species of economic importance in agricultural crops and are often referred to as the short-horned grasshopper.

Life Cycle: Grasshoppers are generalists and feed on a wide range of agricultural crops, such as small grains, flax and sunflowers. Grasshoppers overwinter as eggs, and nymphs start to emerge in late April to early May with peak egg hatch in mid-June. Nymphs (young grasshoppers) will go through five molts before transforming into adults. The length of time from egg to adult is 40 to 60 days. Adults of crop damaging species become numerous in mid-July with egg laying usually beginning in late July and continuing into the fall. Eggs are deposited in a variety of non-crop areas including ditches, shelterbelts, and weedy fall fields.

Damage: Adults and nymphs feed on green plant material, creating holes on leaves or pods. Lentil is less tolerant to grasshopper feeding than some other pulse crops. Grasshoppers pose the greatest threat from the bud stage through early pod development.

Pest Management: Grasshopper outbreaks usually coincide with several years of low rainfall and drought periods. Cool, wet weather increases the diseases that infect and kill grasshoppers. Scout pulse crops for feeding injury from nymphs in the seedling stage, and for adults in the early bud stage through pod development.

Thresholds: For lentils, only two grasshoppers per square yard in the flowering or pod stage can reduce yields enough to warrant insecticide treatment. For other pulse crops (in chickpeas and lentils)**,** the threatening rating is considered the action threshold for grasshoppers. Since it is difficult to estimate the number of grasshoppers per square yard when population densities are high, pest managers can use four 180-degree sweeps with a 15-inch sweep net, which is equivalent to the number of adult (or nymph) grasshoppers per square yard.

	Nymphs per square yard		**Adults per square yard**	
Rating	Margin	Field	Margin	Field
Light	25-35	15-25	10-20	3-7
Threatening	50-75	30-45	21-40	8-14
Severe	100-150	60-90	41-80	15-28
Very Severe	200+	120+	80+	28+

LYGUS BUG (TARNISHED PLANT BUG)

The tarnished plant bug, *Lygus lineolaris*, is one of the more common species and is known to feed on over 385 crops and weed plants. Adult *Lygus* bugs are about ¼ inch in length, and pale green, light brown, or dark brown with a distinctive triangular marking on its back.

Life Cycle: *Lygus* bugs overwinter as adults in weedy areas under debris along fence rows, ditches and roadsides. Adults emerge in early spring, lay eggs in the stems, leaves and flowers of host plants, and then die. Immature nymphs hatch from these eggs and look like aphids. Several generations occur each year with the second generation occurring in mid-July to early August. As with many other insect pests, warm, dry weather favors the buildup of *Lygus* populations and increases the potential for early season damage to peas or lentils. Both immature and adult *Lygus* bugs feed on developing pods and seeds of peas and lentils, and have been linked to "chalk spot."

Damage: Damage is caused by the piercing-sucking mouthpart, which punctures the pods and seed coats injecting a toxic substance into plant parts. Chalk spot is a pit or crater-like depression in the seed coat with or without a discolored chalky appearance. Damage seeds are smaller, deteriorate faster in storage, have poor germination, and produce abnormal seedlings as well as lower the grade and marketability. It is important not to confuse damage caused by *Lygus* bug to damage caused by rough harvesting or handling. For example, peas harvested at high moisture levels are also susceptible to bruising when harvested or handled roughly, resulting in damage similar to chalk spot.

Pest Management: Monitor for *Lygus* bugs using a 15-inch sweep net during bloom to pod development (until seeds within the pod have become firm). Make ten 180 degree sweeps at five sampling sites in a field during the warm sunny part of the day (2-6 PM). *Lygus* populations can increase suddenly. For example, when an alfalfa (preferred host) field is cut, *Lygus* will migrate quickly into nearby pulse crop fields and often in high numbers.

Threshold for Chickpea, Dry Pea and Lentil: No economic threshold has been determined for this region. However, in the Pacific Northwest, an insecticide treatment is recommended when **10 *Lygus* per 25 sweeps** are present. Spray a blooming crop when there is minimal bee activity, preferably during the evening hours (after 8 PM).

PEA APHID

One of the most common insect pests found in pulse crops is the pea aphid. They are small, about 1/8+ inch long and pale to dark green with reddish eyes.

Life Cycle: Pea aphids have multiple generations per year and overwinter as eggs in alfalfa, clover or vetch. In the spring, nymphs hatch from eggs and appear similar to the wingless adult but smaller. Nymphs molt four times and mature into adults in 10 to 14 days. Pea aphids can reproduce rapidly when temperatures are around 65F and relative humidity is near 80 percent. Infestations can originate from local alfalfa fields or can migrate in from the southern states.

Damage: Aphids suck the sap from plants and may vector viral diseases. Populations of only ten aphids per plant can cause economic damage, especially if plants are heat stressed. Pulse crops are especially susceptible in the flowering and early pod stages, when aphid infestations can result in lower yields due to less seed formation and smaller seed size. Protein content and other quality issues do not appear to be affected by aphid feeding. Aphid populations are usually kept low by heavy rains or by beneficial insects (parasitoid wasps) and predators, such as lady bird beetle and lacewings. Early seeding also can reduce damage caused by pea aphids.

Pest Management: Scouting for aphids in pulse crops is conducted by examining the number of aphids per plant tip when 50 to 75 percent of the crop is flowering. Check at least five 8-inch plant tips from four different locations in the field. Population estimates should be calculated by averaging counts taken from four separate areas of the field.

Threshold for Chickpea: There is no recommended economic threshold for aphids in chickpea. To prevent virus infection, it is recommended to select varieties that have virus resistance.

Threshold for Dry Pea: Canadian entomologists suggest the following guidelines. Economic thresholds may vary depending on the value of the crop and cost of control, as well as variation in potential seed weight caused by variation in precipitation and heat stress. The economic threshold in peas at $5.71 per bushel with an average control cost of $6.73-$9.25/acre is 2 to 3 aphids per 8-inch plant tip, or 9 to 12 aphids per sweep (or 90 to 120 aphids per 10 sweeps) at flowering. If the economic threshold is exceeded, a single application of insecticide when 50% of plants have produced some young pods will protect the crop against yield loss and be cost-effective. Cultivars of peas may also vary in their tolerance to feeding by pea aphids, thus economic injury levels may differ between cultivars. The economic threshold presented above was developed using "Century" field peas.

Aphid feeding on peas in the flowering and early pod stage can result in lower yields due to less seed formation and smaller seed size. Protein content and other quality issues do not appear to be affected. The following table relates yield loss in peas for average aphid counts from 1 to 8 aphids per 8-inch pea stem tip when about 25% of the crop has begun to flower.

Aphids per sweep	Aphids per tip	% yield loss
7	1	3.4
10	2	4.9
12	3	6.1
15	4	7.1
16	5	8.0
18	6	8.8
20	7	9.6
21	8	10.3

Research in Manitoba has shown that insecticides applied when pods first form protects pea yield better than earlier or later applications. Control at the early pod stage provides protection through the pod formation and elongation stages, which are very sensitive to aphid damage.

Threshold for Lentil: Insecticide treatment for pea aphid control should be considered (1) when an economic threshold of 30 to 40 aphids are collected per 180° sweep of a 15-inch diameter insect net, (2) when few natural enemies are present, and (3) when aphid numbers do not decline over a 2-day period.

PEA LEAF WEEIVL

A new state record was confirmed for pea leaf weevil, *Sitona lineatus* (L.), near Beach in Golden Valley County, southwestern North Dakota in the fall of 2016. A 2017 field survey found larvae of pea leaf weevil feeding on nitrogen-fixing nodules of field pea in Golden Valley and Stark Counties, and at very low levels on field pea in Ward and Mountrail Counties, north central North Dakota. In 2017, larvae of pea leaf weevil also were detected on nodules of faba beans in Divide County, northwestern North Dakota. Pea leaf weevil is a serious economic pest of field peas and faba beans. This adventive European species is established in the Pacific Northwest, and its range has expanded eastward into southwestern Saskatchewan as far east as Moose Jaw, and central Montana near Lewiston. The North Dakota detection represents a significant range expansion of approximately 250 miles into pea-producing areas of western North Dakota. The adult weevil is brown, small about $^{1}/_{5}$ inch long and feeds on the leaves, chewing a half-circle notch in the leaf edge. The larva is small, legless, cream and C-shaped. Larvae feed on the root nodules and reduce nitrogen-fixing ability of plants and yield.

Threshold: Foliar insecticide treatment for pea leaf weevil control should be applied when **25-33% of the plants have feeding notches on the clam leaves** (recently emerged leaves are still folded together) and before the 6th node growth stage. Some research suggests that insecticidal seed treatments may provide better control than foliar insecticidal sprays.

WIREWORMS

Wireworms are most likely to be problematic in pulse crops when following pasture or grassland. Infestations often are found in coarse textured soils (sandy loam) where moisture is abundant, perhaps in low spots of fields.

Threshold: There is no easy way to estimate wireworm infestations. Two methods are currently used.

Soil Sampling: Sample 20, well spaced, 1 square foot sites to a depth of 4 to 6 inches for every 40 acres being planted. If an average of 1 wireworm per square foot is found, treatment would be justified.

Solar Baiting: In September, establish bait stations for 2 to 3 weeks before freeze. Place bait stations randomly through the field, but representing all areas of the field. There should be 10 - 12 stations per 40 acre field. Place one cup wheat and one cup shelled corn in a 4- to 6-inch deep hole. Cover grain with soil and then an 18-inch square piece of clear plastic. Dig up the grain. If an average of one or more wireworm larvae is found per station, treatment would be justified.

Seed Treatments: Please the seed treatment section in the introduction for more information.

INSECTICIDES REGISTERED FOR USE IN CHICKPEA

Chickpea stems, leaves and seed pods are covered with small, hairlike glandular structures that secrete malic and oxalic acids. The secretions discourage insects from feeding on the plants. Therefore, insect problems on chickpeas have been minimal and insecticide applications generally have not been necessary in North Dakota. Several viral diseases that are transmitted by aphids have occasionally been reported in chickpea fields from the states of Washington and Idaho. Potential insect pests of chickpea include seedcorn maggots, aphids, cutworms, grasshoppers, lygus bugs and wireworms.

INSECTICIDE	PRODUCT PER ACRE	PHI	Aphids	Armyworms	Cutworms	Grasshoppers	Lygus Bugs	Seed Corn Maggot	Wireworms
alpha-cypermethrin Fastac CS *RUP*	**At-plant:** 3.8 fl oz	21 days			●				●
alpha-cypermethrin Fastac CS Fastac EC *RUP*	**Foliar:** 1.3 - 3.8 fl oz	21 days	†	●	●	●	●		
Bacillus thuringiensis* ssp. *kurstaki Biobit HP DiPel DF DiPel ES XenTari DF	 0.5 - 2 lbs 1 - 2 lbs 1 - 4 pts 0.5 - 2 lbs	None		‡	●				
beta-cyfluthrin Baythroid XL *RUP*	0.8 - 3.2 fl oz	7 days Do not feed treated vines or hay	†	‡	●	●	●		
beta-cyfluthrin + imidacloprid Leverage 360 *RUP*	2.4 - 2.8 fl oz	7 days Do not feed treated vines or hay	●	●	●	●			
bifenthrin Bifen 2 AG Gold Bifenture EC Brigade 2EC Fanfare 2EC Sniper Sniper Helios Tundra EC *RUP*	 2.1 - 6.4 fl oz 2.1 - 6.4 fl oz 2.1 - 6.4 fl oz 2.1 - 6.4 fl oz 2.1 - 6.4 fl oz 2.1 - 6.4 fl oz 2.1 - 6.4 fl oz	14 days	●	●	●	●	●		
bifenthrin Bifender FC *RUP*	Broadcast to soil (armyworm and cutworm): 2.9 – 5.9 fl oz At-plant: 0.17 - 0.34 fl oz per 1000 linear feet	None listed		●	●			●	●
bifenthrin Capture LFR Sniper LFR *RUP*	Broadcast to soil (armyworm and cutworm): 3.4 - 6.8 fl oz At-plant: 0.2 - 0.39 fl oz per 1000 linear feet	None listed		●	●			●	●

INSECTICIDE	PRODUCT PER ACRE	PHI	Aphids	Armyworms	Cutworms	Grasshoppers	Lygus Bugs	Seed Corn Maggot	Wireworms
bifenthrin Ethos XB *RUP*	Broadcast to soil (armyworm and cutworm): 3.4 - 8.5 fl oz At-plant: 0.2 - 0.49 fl oz per 1000 linear feet	None listed		●	●			●	●
bifenthrin + imidacloprid Brigadier Skyraider Swagger *RUP*	3.8 - 5.6 fl oz 2.1 - 5.6 fl oz 7.6 - 11.2 fl oz	14 days	●	●	●	●	●		
bifenthrin + zeta-cypermethrin Hero *RUP*	4.0 - 10.3 fl oz	21 days	●	●	●	●	●		
carbaryl Sevin 4F Sevin XLR Plus	0.5 - 1.5 qts 0.5 - 1.5 qts	21 days for seed and hay 14 days for grazing and forage		●	●	●	●		
chlorpyrifos Chlorpyrifos 4E AG Govern 4E Hatchet Lorsban 4E Lorsban Advanced Nufos 4E Vulcan Warhawk Yuma 4E *RUP*	Preplant broadcast: 2 pt At-plant T-band: 1.8 fl oz per 1,000 linear feet at 30” row spacing	None						●	
chlorpyrifos + bifenthrin Match-Up *RUP*	2.05 - 16.4 fl oz	14 days	●	●	●	●	●		
chlorantraniliprole Coragen	3.5 - 5 fl oz	1 day		●					
chlorantraniliprole + lambda-cyhalothrin Besiege *RUP*	5 - 9 fl oz	21 days	●	●	●	●	●		
cyantraniliprole Exirel	10 - 20.5	7 days		●	●				
cyfluthrin Tombstone Tombstone Helios *RUP*	0.8 - 3.2 fl oz 0.8 - 3.2 fl oz	7 days Do not feed treated vines or hay	†	‡	●	●	●		
dimethoate Dimethoate 4E Dimethoate 400	0.5 - 1 pt	None Do not feed vines	●			●	●		
esfenvalerate Asana XL *RUP*	5.8 - 9.6 fl oz	21 days Do not feed or graze treated vines	●		●	●			
flupyradifurone Sivanto Prime	7 - 10.5 fl oz	7 days	●						
gamma-cyhalothrin Declare *RUP*	0.77 - 1.54 fl oz	21 days Do not graze or feed treated vines	●	●	●	●	●		

INSECTICIDE	PRODUCT PER ACRE	PHI	Aphids	Armyworms	Cutworms	Grasshoppers	Lygus Bugs	Seed Corn Maggot	Wireworms
imidacloprid Attendant 480FS Attendant 600 Dyna-Shield Imidacloprid 5 Gaucho 600 Senator 600FS	**COMMERCIAL SEED TREATMENT ONLY** 2 - 4 fl oz per cst 1.6 - 3.2 fl oz per cwt 1.6 - 3.2 fl oz per cwt 1.6 - 3.2 fl oz per cwt 1.6 - 3.2 fl oz per cwt	Not indicated	●						●
imidacloprid Enhance AW	5 oz per cwt	Do not graze or feed livestock on treated area for 60 days after planting	●						●
imidacloprid Pasada 1.6F Prey 1.6F Sherpa	Foliar application: 3.5 fl oz	7 days	●						
imidacloprid Alias 2F AmTide Imidacloprid 2F Malice 2F Montana 2F Nuprid 2SC Widow	Soil applications: 16.0 - 24.0 fl oz	21 days	●						
imidacloprid AmTide Imidacloprid 2F Nuprid 2SC	Foliar application: 2.8 fl oz	7 days	●						
imidacloprid ADAMA Alias 4F Advise Four Montana 4F Nuprid 4F Max Wrangler	Soil applications: 8.0 - 12.0 fl oz	21 days	●						
imidacloprid ADAMA Alias 4F Advise Four Montana 4F Nuprid 4F Max	Foliar application: 1.4 fl oz	7 days	●						
imidacloprid Admire Pro Nuprid 4.6F Pro	Soil applications: 7.0 - 10.5 fl oz	21 days	●						
imidacloprid Admire Pro	Foliar application: 1.2 fl oz	7 days	●						
imidacloprid Malice 75WSP	0.9 oz	7 days	●						
lambda-cyhalothrin Grizzly Too Kendo Lambda-Cy EC LambdaStar Lambda-T Lamcap Nufarm Lambda-Cyhalothrin 1EC Paradigm VC Province Silencer Silencer VXN Warrior II *RUP*	0.96 - 1.92 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 0.96 - 1.92 fl oz	21 days Do not graze or harvest vines for forage or hay	●	●	●	●	●		

INSECTICIDE	PRODUCT PER ACRE	PHI	Aphids	Armyworms	Cutworms	Grasshoppers	Lygus Bugs	Seed Corn Maggot	Wireworms
methomyl Lannate LV *RUP*	1.5 - 3 pts	14 days	●	●	●		●		
methoxyfenozide Intrepid 2F	4 - 8 fl oz (early season) 8 - 16 fl oz (late season)	7 days		●					
spinosad Blackhawk Entrust Spintor 2SC	2.2 - 3.3 oz 1.25 - 2 oz 4 - 6 fl oz	28 days Do not feed forage or hay		‡					
spinetoram Radiant SC	4 - 8 fl oz	28 days		‡					
spirotetramat Movento Movento HL	4 - 5 fl oz 2 - 2.5 fl oz	7 days	●						§
sulfoxaflor Transform WG	0.75 - 1 oz	7 days	●						
thiamethoxam Cruiser 5FS Cruiser Maxx Cruiser Maxx Vibrance Pulses	1.28 fl oz per cwt 3 fl oz per cwt 5 fl oz per cwt	None	●					●	●
zeta-cypermethrin Mustang Maxx Mustang Maxx EC *RUP*	At plant T-band or in-furrow application: 4 fl oz	Not indicated			●				●
zeta-cypermethrin Mustang Maxx *RUP*	1.4 - 4.3 fl oz 1.28 - 4 fl oz	21 days	●	●	●	●	●		

RUP = Restricted Use Pesticide
● = Control
† = Suppression only §= Wireworm suppression only
‡ = Control of first and second instar larvae

INSECTICIDES REGISTERED FOR USE IN DRY PEA

INSECTICIDE	PRODUCT PER ACRE	PHI	Aphids	Cutworms	Grasshoppers	Pea Leaf Weevil Adults	Pea Leaf Weevil Larvae	Lygus Bugs	Wireworms
alpha-cypermethrin Fastac CS *RUP*	At-plant: 3.8 fl oz	21 days		●					●
alpha-cypermethrin Fastac CS Fastac EC *RUP*	Foliar: 1.3 - 3.8 fl oz	21 days	†	●	●	●		●	
beta-cyfluthrin Baythroid XL *RUP*	0.8 - 3.2 fl oz	7 days Do not feed treated vines or hay	†	●	●	●		●	
beta-cyfluthrin + imidacloprid Leverage 360 *RUP*	2.4 - 2.8 fl oz	7 days Do not feed treated vines or hay	●	●	●				
bifenthrin Bifen 2 AG Gold Bifenture EC Brigade 2EC Fanfare 2EC Sniper Sniper Helios Tundra EC *RUP*	2.1 - 6.4 fl oz 2.1 - 6.4 fl oz 2.1 - 6.4 fl oz 2.1 - 6.4 fl oz 2.1 - 6.4 fl oz 2.1 - 6.4 fl oz 2.1 - 6.4 fl oz	14 days	●	●	●	●		●	
bifenthrin Bifender FC *RUP*	Broadcast to soil (cutworm): 2.9 – 5.9 fl oz At-plant: 0.17 - 0.34 fl oz per 1000 linear feet	None listed		●					●
bifenthrin Capture LFR Sniper LFR *RUP*	Broadcast to soil (cutworm): 3.4 - 6.8 fl oz At-plant: 0.2 - 0.39 fl oz per 1000 linear feet	None listed		●					●
bifenthrin Ethos XB *RUP*	Broadcast to soil (cutworm): 3.4 - 8.5 fl oz At-plant: 0.2 - 0.49 fl oz per 1000 linear feet	None listed		●					●
bifenthrin + imidacloprid Brigadier Skyraider Swagger *RUP*	3.8 - 5.6 fl oz 2.1 - 5.6 fl oz 7.6 - 11.2 fl oz	14 days	●	●	●	●		●	
bifenthrin + zeta-cypermethrin Hero *RUP*	4.0 - 10.3 fl oz	21 days	●	●	●	●		●	
carbaryl Sevin 4F Sevin XLR Plus	0.5 - 1.5 qts 0.5 - 1.5 qts	21 days for seed and hay 14 days for grazing and forage		●	●	●		●	

INSECTICIDE	PRODUCT PER ACRE	PHI	Aphids	Cutworms	Grasshoppers	Pea Leaf Weevil Adults	Pea Leaf Weevil Larvae	Lygus Bugs	Wireworms
chlorantraniliprole + lambda-cyhalothrin Besiege *RUP*	5 - 9 fl oz	21 days	●	●	●			●	
chlorpyrifos + bifenthrin Match-Up *RUP*	2.05 - 16.4 fl oz	14 days	●	●	●	●		●	
cyantraniliprole Exirel	10 - 20.5	7 days		●					
cyfluthrin Tombstone Tombstone Helios *RUP*	0.8 - 3.2 fl oz 0.8 - 3.2 fl oz	7 days Do not feed treated vines or hay	†	●	●	●		●	
esfenvalerate Asana XL *RUP*	5.8 - 9.6 fl oz	21 days Do not feed or graze treated vines	●	●	●				
flupyradifurone Sivanto Prime	7 - 10.5 fl oz	7 days	●						
gamma-cyhalothrin Declare *RUP*	0.77 - 1.54 fl oz	21 days Do not graze or feed treated vines	●	●	●			●	
imidacloprid Attendant 480 FS Attendant 600 Dyna-Shield Imidacloprid 5 Gaucho 600 Senator 600FS	**COMMERCIAL SEED TREATMENT ONLY** 2 - 4 fl oz per cwt 1.6 - 3.2 fl oz per cwt 1.6 - 3.2 fl oz per cwt 1.6 - 3.2 fl oz per cwt 1.6 - 3.2 fl oz per cwt	None	●						●
imidacloprid Enhance AW	5 oz per cwt	Do not graze or feed livestock on treated area for 60 days after planting	●						●
imidacloprid Pasada 1.6F Prey 1.6F Sherpa	Foliar application: 3.5 fl oz	7 days	●						
imidacloprid ADAMA Alias 2F AmTide Imidacloprid 2F Malice 2F Montana 2F Nuprid 2SC Widow	Soil applications: 16.0 - 24.0 fl oz	21 days	●						
imidacloprid AmTide Imidacloprid 2F Nuprid 2SC	Foliar application: 2.8 fl oz	7 days	●						
imidacloprid ADAMA Alias 4F Advise Four Montana 4F Nuprid 4F Max Wrangler	Soil applications: 8.0 - 12.0 fl oz	21 days	●						
imidacloprid ADAMA Alias 4F Advise Four Montana 4F Nuprid 4F Max	Foliar application: 1.4 fl oz	7 days	●						

INSECTICIDE	PRODUCT PER ACRE	PHI	Aphids	Cutworms	Grasshoppers	Pea Leaf Weevil Adults	Pea Leaf Weevil Larvae	Lygus Bugs	Wireworms
imidacloprid Admire Pro Nuprid 4.6F Pro	Soil applications: 7.0 - 10.5 fl oz	21 days	●						
imidacloprid Admire Pro	Foliar application: 1.2 fl oz	7 days	●						
imidacloprid Malice 75WSP	0.9 oz	7 days	●						
lambda-cyhalothrin Grizzly Too Kendo Lambda-Cy EC LambdaStar Lambda-T Lamcap Nufarm Lambda-Cyhalothrin 1EC Paradigm VC Province Silencer Silencer VXN Warrior II *RUP*	0.96 - 1.92 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 0.96 - 1.92 fl oz	21 days Do not graze or harvest vines for forage or hay	●	●	●	●		●	
spirotetramat Movento Movento HL	4 - 5 fl oz 2 - 2.5 fl oz	7 days	●						†
thiamethoxam Cruiser 5FS Cruiser Maxx Cruiser Maxx Vibrance Pulses	1.28 fl oz per cwt 3 fl oz per cwt 5 fl oz per cwt	None	●				†		●
zeta-cypermethrin Mustang Maxx Mustang Maxx EC *RUP*	At plant T-band or in-furrow application: 4 fl oz	None		●					●
zeta-cypermethrin Mustang Maxx *RUP*	1.4 - 4.3 fl oz 1.28 - 4 fl oz	21 days	●	●	●	●		●	

RUP = Restricted Use Pesticide
● = Control
† = Suppression Only

INSECTICIDES REGISTERED FOR USE IN LENTIL

INSECTICIDE	PRODUCT PER ACRE	PHI	Cutworms	Grasshoppers	Lygus Bugs	Pea Aphid	Wireworms
alpha-cypermethrin Fastac CS *RUP*	**At-plant:** 3.8 fl oz	21 days	●				●
alpha-cypermethrin Fastac CS Fastac EC *RUP*	**Foliar:** 1.3 - 3.8 fl oz	21 days	●	●	●	†	
beta-cyfluthrin Baythroid XL *RUP*	0.8 - 3.2 fl oz	7 days Do not feed treated vines or hay	●	●	●	†	
beta-cyfluthrin + imidacloprid Leverage 360 *RUP*	2.4 - 2.8 fl oz	7 days Do not feed treated vines or hay	●	●		●	
bifenthrin Bifen 2 AG Gold Bifenture EC Brigade 2EC Fanfare 2EC Sniper Sniper Helios Tundra EC *RUP*	2.1 - 6.4 fl oz 2.1 - 6.4 fl oz 2.1 - 6.4 fl oz 2.1 - 6.4 fl oz 2.1 - 6.4 fl oz 2.1 - 6.4 fl oz 2.1 - 6.4 fl oz	14 days	●	●	●	●	
bifenthrin Bifender FC *RUP*	Broadcast to soil (cutworm): 2.9 – 5.9 fl oz At-plant: 0.17 - 0.34 fl oz per 1000 linear feet	None listed	●				●
bifenthrin Capture LFR Sniper LFR *RUP*	Broadcast to soil (cutworm): 3.4 - 6.8 fl oz At-plant: 0.2 - 0.39 fl oz per 1000 linear feet	None listed	●				●
bifenthrin Ethos XB *RUP*	Broadcast to soil (cutworm): 3.4 - 8.5 fl oz At-plant: 0.2 - 0.49 fl oz per 1000 linear feet	None listed	●				●
bifenthrin + imidacloprid Brigadier Skyraider Swagger *RUP*	3.8 - 5.6 fl oz 2.1 - 5.6 fl oz 7.6 - 11.2 fl oz	14 days	●	●	●	●	
bifenthrin + zeta-cypermethrin Hero *RUP*	4.0 - 10.3 fl oz	21 days	●	●	●	●	
carbaryl Sevin 4F Sevin XLR Plus	0.5 - 1.5 qts 0.5 - 1.5 qts	21 days for seed and hay 14 days for grazing and forage	●	●	●		

INSECTICIDE	PRODUCT PER ACRE	PHI	Cutworms	Grasshoppers	Lygus Bugs	Pea Aphid	Wireworms
chlorantraniliprole + lambda-cyhalothrin Besiege *RUP*	5 - 9 fl oz	21 days	●	●	●	●	
chlorpyrifos + bifenthrin Match-Up *RUP*	2.05 - 16.4 fl oz	14 days	●	●	●	●	
cyantraniliprole Exirel	10 - 20.5	7 days	●				
cyfluthrin Tombstone Tombstone Helios *RUP*	0.8 - 3.2 fl oz 0.8 - 3.2 fl oz	7 days Do not feed treated vines or hay	●	●	●	†	
dimethoate Dimate 4E Dimethoate 4E Dimethoate 4EC Dimethoate 400	0.5 - 1 pt	14 days Do not feed vines			●	●	
esfenvalerate Asana XL *RUP*	5.8 - 9.6 fl oz	21 days Do not feed or graze treated vines	●	●		●	
flupyradifurone Sivanto Prime	7 - 10.5 fl oz	7 days				●	
gamma-cyhalothrin Declare *RUP*	0.77 - 1.54 fl oz	21 days Do not graze or feed treated vines	●	●	●	●	
imidacloprid Attendant 480FS Attendant 600 Dyna-Shield Imidacloprid 5 Gaucho 600 Senator 600FS	**COMMERCIAL SEED TREATMENT ONLY** 2 - 4 fl oz per cwt 1.6 - 3.2 fl oz per cwt 1.6 - 3.2 fl oz per cwt 1.6 - 3.2 fl oz per cwt 1.6 - 3.2 fl oz per cwt	None				‡	●
imidacloprid Enhance AW	5 oz per cwt	Do not graze or feed livestock on treated area for 60 days after planting				‡	●
imidacloprid Pasada 1.6F Prey 1.6F Sherpa	Foliar application: 3.5 fl oz	7 days				●	
imidacloprid ADAMA Alias 2F AmTide Imidacloprid 2F Malice 2F Montana 2F Nuprid 2SC Widow	Soil applications: 16.0 - 24.0 fl oz	21 days				‡	
imidacloprid AmTide Imidacloprid 2F Nuprid 2SC	Foliar application: 2.8 fl oz	7 days				●	
imidacloprid ADAMA Alias 4F Advise Four Montana 4F Nuprid 4F Max Wrangler	Soil applications: 8.0 - 12.0 fl oz	21 days				‡	

INSECTICIDE	PRODUCT PER ACRE	PHI	Cutworms	Grasshoppers	Lygus Bugs	Pea Aphid	Wireworms
imidacloprid ADAMA Alias 4F Advise Four Montana 4F Nuprid 4F Max	Foliar application: 1.4 fl oz	7 days				●	
imidacloprid Admire Pro Nuprid 4.6F Pro	Soil applications: 7.0 - 10.5 fl oz	21 days				‡	
imidacloprid Admire Pro	Foliar application: 1.2 fl oz	7 days				●	
imidacloprid Malice 75WSP	0.9 oz	7 days				●	
lambda-cyhalothrin Grizzly Too Kendo Lambda-Cy EC LambdaStar Lambda-T Lamcap Nufarm Lambda-Cyhalothrin 1EC Paradigm VC Province Silencer Silencer VXN Warrior II *RUP*	0.96 - 1.92 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 0.96 - 1.92 fl oz	21 days Do not graze or harvest vines for forage or hay	●	●	●	●	
spirotetramat Movento Movento HL	4 - 5 fl oz 2 - 2.5 fl oz	7 days				●	†
thiamethoxam Cruiser 5FS Cruiser Maxx Cruiser Maxx Vibrance Pulses	1.28 fl oz per cwt 3 fl oz per cwt 5 fl oz per cwt	None				‡	●
zeta-cypermethrin Mustang Maxx Mustang Maxx EC *RUP*	At plant T-band or in-furrow application: 4 fl oz	None	●				
zeta-cypermethrin Mustang Maxx *RUP*	1.4 - 4.3 fl oz 1.28 - 4 fl oz	21 days	●	●	●	●	

RUP = Restricted Use Pesticide
● = Control
† = Suppression only
‡ = Early season Pea Aphid control only

RANGELAND AND NON-CROP SITES

GRASSHOPPER MANAGEMENT

Summary of North Dakota Law Regarding Grasshopper Control Along Roadsides

***Townships and Counties*:** Townships and counties are authorized to control grasshoppers infesting road rights of way under their authority (1991 law).

Requirements

- Pesticides **must be labeled** for use on forage crops so they **may be hayed**
- Written notice to all landowners or tenants 3 days prior to treatment
  - Date of treatment
  - Name of pesticide and restrictions on harvest and use of forage
  - Must exclude areas opposed by adjacent landowner or occupant

***State Highway Rights of Way*:** Counties may enter into agreement with DOT to control grasshoppers in state highway system rights of way. (Contact DOT district office)

North Dakota Department of Agriculture must approve plan when state funds involved (Contact North Dakota Department of Agriculture at 701.328.4765)

- Request for approval form is submitted by County Pest Coordinator
- Plan must include county or township roads
- Scouting to verify economic infestation
- Treatments must be made prior to adult stage

Financing Summary

Counties: Governing body may use county emergency fund (57-15-28) to pay for control costs in county road system rights of way and for cost share with townships.

Maximum balance

- 5 mills for large counties (Burleigh, Cass, Grand Forks, Ward)
- 10 mills for small counties

Tax limitation for emergency purposes (57-15-06.7)

- Tax for emergency purposes not to exceed 2 mills.

Townships: Electors may appropriate funds (57-15-19) for controlling grasshoppers in township rights of way. Total annual tax levy (for all purposes) in a civil township may not exceed 18 mills.

Rangeland

Roadside Right of Way Grasshopper Spray Program Considerations

Treatment of grasshoppers when they are young, concentrated in hatching areas, and highly susceptible to lower rates of insecticide is a long standing management strategy. Roadside rights of way are sometimes major hatching areas for grasshoppers. Infestations are often variable and not all roadsides are likely to be infested. Roadsides that were weedy or had enough green vegetation to attract adult grasshoppers during the previous year's egg-laying period are more likely to be infested with eggs. Roadsides adjacent to late-season crops that are themselves attractive egg-laying sites are also more heavily infested.

Numerous other areas on the farm can also be hatching areas, including fencerows, shelterbelts, rock piles, grass waterways, weedy waste areas, some CRP, alfalfa and haylands, and last year's weedy fallow and weedy fields. Fields planted to a late-season crop last year, such as sunflower, safflower, flax and soybean, are attractive especially when summer-fallowed this year.

Treatment timing can be difficult. Egg hatch normally occurs over a 4 - 6 week period and the developing grasshoppers gradually move out from their hatching areas. Spraying too early can miss later hatching grasshoppers while spraying too late allows early hatching hoppers to move into crops and escape treatment and perhaps cause serious crop damage.

What are Reasonable Expectations

1. Roadside programs conducted when roadsides are generally infested and a major contributor as hatching areas can reduce but not eliminate the threat of grasshopper damage.
2. Farmers may be disappointed if they do not make efforts to identify, monitor, and manage other hatching areas.
3. Roadside programs may reduce, but are unlikely to eliminate, the need for additional crop protection measures in years favorable for grasshoppers.
4. Roadside programs may contribute to, but are unlikely to be responsible for, preventing grasshoppers from laying eggs and creating the potential for problems next year.

Roadside Programs should:

1. Include scouting to determine if a sufficient percentage of roadsides are infested to warrant a roadside program. Roadside infestations are frequently spotty and other areas frequently contribute to the grasshopper problem.
2. Treatments should generally be applied prior to significant movement of grasshoppers into fields. Movement normally begins as hoppers approach the 3rd instar. Treatments after adults appear are not effective.
3. Farmers should be encouraged to scout and if necessary treat other hatching areas with threatening populations.

GRASSHOPPERS

Threshold: The threatening rating is considered the action threshold for grasshoppers. Since it is difficult to estimate the number of grasshoppers per square yard when population densities are high, pest managers can use four 180-degree sweeps with a 15-inch sweep net, which is equivalent to the number of adult (or nymph) grasshoppers per square yard.

	Nymphs per square yard		Adults per square yard	
Rating	Margin	Field	Margin	Field
Light	25-35	15-25	10-20	3-7
Threatening	50-75	30-45	21-40	8-14
Severe	100-150	60-90	41-80	15-28
Very Severe	200+	120+	80+	28+

INSECTICIDES REGISTERED FOR USE ON RANGELAND AND/OR NON-CROP AREAS: GRAZED OR CUT FOR HAY

INSECTICIDE	PRODUCT PER ACRE	PHI	Rangeland	Non-crop Areas
beta-cyfluthrin Baythroid XL *RUP*	1.6 - 2.8 fl oz	None for grazing and haying	●	
carbaryl Sevin 4F Sevin SL Sevin XLR Plus	0.5 - 1 qt 0.5 - 1 qt 0.5 - 1 qt	14 days for grazing and haying for pastures and non-crop areas None for grazing and haying for rangeland	●	●
chlorantraniliprole Prevathon	14 - 20 fl oz	None	●	
chlorantraniliprole + lambda-cyhalothrin Besiege *RUP*	5 - 10 fl oz	0 days for grazing 7 days for haying	●	
cyfluthrin Tombstone Tombstone Helios *RUP*	1.6 - 2.8 fl oz 1.6 - 2.8 fl oz	None for grazing and haying 7 days for grazing and haying in mixed stands with alfalfa	●	
diflubenzuron Dimilin 2L *RUP*	0.5 - 2 fl oz Use high rate for non-crop areas	1 day for haying	●	●
gamma-cyhalothrin Declare *RUP*	0.77 - 1.54 fl oz	0 days for grazing 7 days for haying	●	
lambda-cyhalothrin Grizzly Too Kendo Lambda-Cy EC LambdaStar Lambda-T Lamcap Nufarm Lambda Cyhalothrin 1EC Paradigm VC Province Silencer Silencer VXN Warrior II *RUP*	0.96 - 1.92 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 0.96 - 1.92 fl oz	None for grazing and forage 7 days for haying	●	

Rangeland

INSECTICIDE	PRODUCT PER ACRE	PHI	Rangeland	Non-crop Areas
malathion				
Fyfanon ULV AG	8 - 12 fl oz	None for grazing, forage and haying	●	
Malathion 5	1.5 - 2.25 pts			
zeta-cypermethrin				
Mustang Maxx *RUP*	2.24 - 4 fl oz	None for grazing, forage and haying 7 days for straw	●	

RUP = Restricted Use Pesticide

INSECTICIDES REGISTERED FOR USE ON NON-CROP AREAS: NOT GRAZED OR CUT FOR HAY

INSECTICIDE	PRODUCT PER ACRE	COMMENTS
acephate		
Acephate 90 Prill	4.4 oz	
Acephate 90 WDG	0.28 lb	
Acephate 97	4 oz	
Acephate 97 UP	4 oz	
carbaryl		
Sevin 4F	0.5 - 1 qt	
Sevin SL	0.5 - 1 qt	
Sevin XLR Plus	0.5 - 1 qt	
diflubenzuron		
Dimilin 2L *RUP*	0.5 - 2 fl oz Use high rate for non-crop areas	
esfenvalerate		
Asana XL *RUP*	2.9 - 9.6 fl oz	Not labeled for use on public lands
gamma-cyhalothrin		
Declare *RUP*	0.77 - 1.54 fl oz	Not labeled for use on public lands
lambda-cyhalothrin		
Grizzly Too	0.96 - 1.92 fl oz	Not labeled for use on public lands
Kendo	1.92 - 3.84 fl oz	
Lambda-Cy EC	1.92 - 3.84 fl oz	
LambdaStar	1.92 - 3.84 fl oz	
Lambda-T	1.92 - 3.84 fl oz	
Lamcap	1.92 - 3.84 fl oz	
Nufarm Lambda Cyhalothrin 1EC	1.92 - 3.84 fl oz	
Paradigm VC	1.92 - 3.84 fl oz	
Province	1.92 - 3.84 fl oz	
Silencer	1.92 - 3.84 fl oz	
Silencer VXN	1.92 - 3.84 fl oz	
Warrior II *RUP*	0.96 - 1.92 fl oz	

RUP = Restricted Use Pesticide

MOSQUITO CONTROL IN PASTURES

Mosquito swarms can cause reduced feeding in livestock, which in turn can lead to lower body weight and decreased milk production. Some *Culex* mosquito species vector West Nile Virus and viruses that cause encephalitis. These viruses are especially dangerous to horses. Standing, stagnant water is essential for mosquito reproduction. Mosquitoes can complete a single reproductive cycle in as little as four days. The main strategies to reduce mosquito populations are:

- Reduce standing water. If possible, drain wet areas in pastures that typically hold water for more than a week. Clean and replenish water tanks and troughs at least once a week, and do not allow water to pool around tanks. Remove other sources of standing water such as old tires, old water tanks, pails, barrels and anything else that can create stagnant water. If possible, avoid grazing poorly drained areas after a heavy rain, as deep hoofprints can hold ample water for mosquito reproduction.
- Keep weeds trimmed around watering areas, ditches and fencelines to reduce resting habitat for adult mosquitoes.
- Apply labeled wipes or sprays to livestock and horses for temporary relief from mosquitoes. If possible, keep livestock and horses in barns at night to reduce mosquito bites, especially during wet spells with high mosquito numbers.
- Persistent standing water that cannot be drained can be treated with larvicidal products to control mosquito larvae. These include *Bacillus thuringiensis israelensis* (Bti), *Bacillus sphaericus* (Bs), methoprene and film-forming oils. Consequently, applications must be made before larvae reach the pupal stage, with the exception of film-forming oils which prevent pupae from adhering to the water surface.
- Foliar-applied pyrethroid and malathion products registered for use in grazed pastures and rangeland may provide temporary control of adult mosquitoes. However, it may not be feasible to treat an entire pasture. Instead, focus applications along fencelines and other areas with resting habitat for adult mosquitoes.

INSECTICIDES REGISTERED FOR CONTROL OF MOSQUITO LARVAE

INSECTICIDE	PRODUCT RATES	COMMENTS
***Bacillus thuringiensis* subsp. *israelensis* (Bti)** Aquabac 200 G Aquabac 400 G Mosquito Dunks VectoBac G	 2.5 - 10 lbs per acre 1.25 5 lbs per acre Consult label 2.5 - 10 lbs per acre	Consult product labels for application directions and use restrictions
***Bacillus thuringiensis* subsp. *sphaericus* (Bts)** VectoLex FG VectoLex WDG VectoLex WSP VectoMax FG* VectoMax WSP*	 5 - 20 lbs per acre 0.5 - 1.5 lbs per acre 1 pouch per 50 square feet 5 - 20 lbs per acre 1 pouch per 50 square feet	Consult product labels for application directions and use restrictions
methoprene Altosid (several products)	Consult labels	Consult product labels for application directions and use restrictions
monomolecular film Agnique MMF	0.2 - 1 gal per acre	Consult product labels for application directions and use restrictions

*VectoMax products contain both Bti and Bts.

SAFFLOWER INSECTS

Safflower may be infested from the time of emergence to maturity by various insect pests. The most susceptible periods is the bud to flower stage. Fields should be examined regularly and controls applied when infestations are damaging.

CUTWORMS

Several species of cutworms (*Agrotis* spp.) attack safflower. Cutworms are caterpillars that live below ground and cut off seedling at or just below the soil line. Areas in the field are often barren following cutworm feeding. If sufficient plants are present, safflower can compensate for some seedling loss. If damage is severe, protection of seedlings with insecticide may be necessary. There is no known economic threshold for cutworms in safflower in North Dakota.

WIREWORMS

Wireworms, although often serious pests of cereal grains in the seedling stage, seldom damage safflower. Imidacloprid and thiamethoxam are labeled as commercial seed treatment and use decisions must be made at time of seed purchase. Please the seed treatment section in the introduction for more information.

INSECTICIDES REGISTERED FOR USE IN SAFFLOWER

INSECTICIDE	PRODUCT PER ACRE	PHI	Cutworms	Wireworms
cyantraniliprole Fortenza[1]	0.1 - 0.2 mg ai per seed or 0.56 – 1.1 fl oz per 100,000 seeds	None. Consult label for rotational crop restrictions.	●	●
imidacloprid Dyna-Shield Imidacloprid 5 Gaucho 600F Senator 600FS	12.8 fl oz per cwt	None		●
thiamethoxam Cruiser 5FS	10.24 fl oz per cwt	None		●
zeta-cypermethrin Mustang Maxx *RUP*	4 fl oz	14 days	●	

RUP = Restricted Use Pesticide
● = Control
[1]May provide protection against wireworm when combined with Cruiser 5FS

Safflower

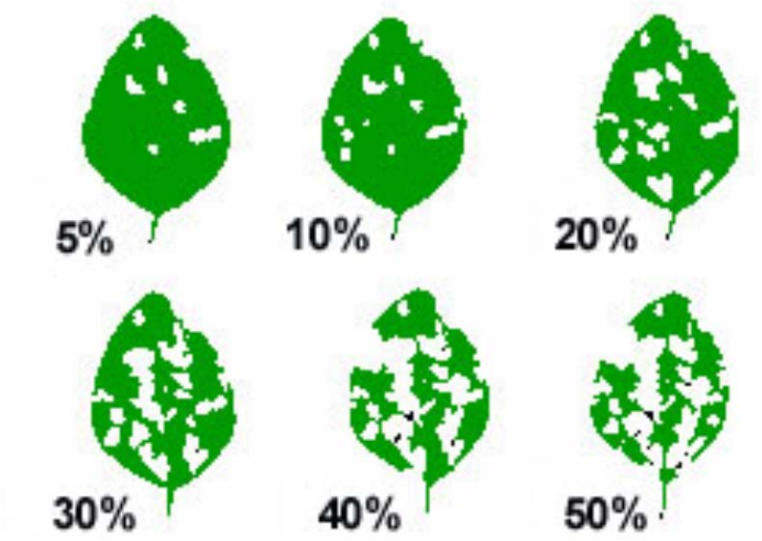
SOYBEAN INSECTS

Other Resources Available Through NDSU Extension Service:

Publications	A1172	Soybean Production Field Guide for North Dakota (2019)
	E268	The Effectiveness of Neonicotinoid Seed Treatments in Soybean (2015) - Web only at: https://www.ag.ndsu.edu/extensionentomology/field-crops-insect-pests/soybean
	CSI-0060	Soybean Aphid Field Guide - NCSRP (2013)
	E830	The Armyworm and the Army Cutworm (revised 2018)
	E1878	Management of Insecticide-resistant Soybean Aphids (2019)

Estimating Damage Caused by Defoliating Insects

In soybeans, field scouting to assess insect populations is based on either the number of insects per foot of row, insects per plant, or the level of defoliation. Insects per foot of row is determined by shaking plants over the inter-row space, on which a strip of cloth has been laid. Count the total number of insect pests per foot of row that fall on the cloth. If sampling a narrow row or drilled soybeans, the use of a "Texas vertical beat sheet" should be considered. The vertical beat sheet is made from a piece of galvanized metal flashing or similar stiff material, 36 inches wide, 32 inches tall and crimped at the bottom to form a collecting trough 4 inches wide. Place the device next to the row and shake the plants against the vertical surface. Insects dislodged from plants collect in the trough where they can be counted or collected. Percent defoliation is determined by estimating the amount of leaf loss based on visual inspection of randomly selected plants. The growth stage of the soybean plant is important. Under most conditions, moderate defoliation early in the season has little effect on final bean yield. As plants reach the flowering and pod filling stages, then defoliation poses a greater threat to yield. For example, research indicates that the soybean plant can sustain a 35% leaf loss prior to the pre-bloom period. From pod-set to maturity, the plant can tolerate only a 20% defoliation level.



ARMYWORMS

Armyworms are greenish-brown with longitudinal stripes. Full grown larvae are smooth, striped and almost hairless. Armyworms feed for three to four weeks. When full grown, larvae are 1½ to 2 inches in length. Armyworm larvae have six growth stages, or instars. The armyworm's final instar lasts about 10 days and they consume large amounts of plant material during that time.

Armyworms are inactive during the day, resting under plant trash, and clumps of grass or lodged plants. They feed at night or on cloudy days, crawling up on plants and consuming foliage. Due to their habit of feeding at night, armyworms may go undetected until significant damage has occurred. Armyworms do not overwinter in the region. The moths migrate from Southern states in late spring and early summer. This helps explain the sporadic infestations that occur. When moths arrive, they prefer to lay their eggs in moist, shady areas, usually where grasses have lodged. Infestations that develop within soybean fields are often due to grassy weed problems. Armyworms are more of a problem in small grains and corn. Damage to soybeans can occur when the armyworm's usual host plants become exhausted due to feeding or dry conditions. When their food is depleted in the hatching site, the armyworms may move in large numbers, or "armies," eating and destroying plants or crops in their path.

Threshold: Control of armyworms is recommended when 25% to 30% of the foliage is destroyed or if significant injury to pods is evident. Most often in soybeans, infestations are due to migrating armyworms. Under these circumstances, treatment of a couple of swaths ahead of the migrating armyworms to establish a barrier strip is suggested to prevent further migration and injury.

BEAN LEAF BEETLE

Bean leaf beetles have been increasing in North Dakota over the past years. Adult bean leaf beetles emerge from overwintering sites and moving into soybean or dry bean fields. The adults are yellow to reddish-brown and three to four black spots with a black border on wing covers. Adults emerge from overwintering, moving into bean fields as the seedlings emerge. The white larvae develop in the soil,

feeding on the roots and nodules. New adults emerging in August feed on foliage and pods. Feeding injury to leaves appears as small round holes between the leaf veins. Injury to pods appears as lesions similar in size and shape to leaf-feeding holes. The injury to pods results in secondary infections by fungi and bacteria, causing rotting and discoloration.

Threshold: Treatment thresholds from other regions are 3 to 7 beetles per sweep or based on defoliation: 50% defoliation during early vegetative, 40% defoliation during pre-bloom, 35% defoliation during bloom and 20-25% defoliation or 10% pod feeding (or the presence of clipped pods) or 0.5 beetle/plant during pod set to fill. Late season feeding on the foliage and pods by the new adults that emerge in August appears to be more important than early season feeding. This may increase the risk of virus transmission and cause secondary infections (rotting and discoloration) from fungi and bacteria.

CUTWORMS

Several cutworm species affect regional crops. The dingy cutworm, *Feltia jaculifera*, overwinters as a partially grown larva and is one of the first cutworm species to cause problems during crop emergence from early to mid-May. The moth of the dingy cutworm is known to lay her eggs on sunflower heads from mid-July through September. Soybeans and other crops following sunflowers in rotation are at greatest risk of injury by this cutworm. Other cutworms, the red-backed, *Exoa ochregaster*, and the darksided, *Exoa messoria*, overwinter as eggs which hatch in mid to late May. Eggs are laid in the fall and survive in weedy, wet and reduced tillage areas. Feeding injury by these cutworms normally occurs in late May to early June. Most damage by cutworms occurs when soybean plants are in the early stage of development. Damage consists of young plants being chewed off slightly below or at ground level. Some cutworm feeding injury may occur on foliage. Cutworms primarily feed at night. When checking soybean fields for cutworms during the day, dig down into soil an inch or two around recently damaged plants; there you can find the gray to gray-brown larva.

Threshold: Economic thresholds for cutworm treatment decisions are not well established. Treatment guidelines used over the years include when one cutworm or more is found per 3 feet of row and the larvae are small (<3/4 inch long). Another guideline is when 20% of plants are cut or when gaps of 1 foot or more exist in the plant row. When making a final decision, consider that surviving soybeans are able to compensate for early stand reductions because of the plant's long growth period.

FOLIAGE FEEDING CATERPILLARS

Green Cloverworm, Cabbage Looper, Velvetbean Caterpillar, Thistle Caterpillar and Alfalfa Webworm

Populations of these caterpillars have been negligible in North Dakota and little treatment to control them has been required. Sampling for these insects is accomplished through the use of a drop cloth or a vertical beat sheet, placed between two rows of plants. The larvae are dislodged from the plants and counted on the cloth or collection tray to arrive at an estimate of the number per row feet.

Green cloverworm: These caterpillars are green with two narrow, white stripes down the side. When mature, the worms are 1 ¼ inches long. These caterpillars have only three pairs of fleshy prolegs on the abdomen, plus a pair of prolegs on the back segment. When moving, the worms move by arching the middle of the body, or "looping." Young worms scrape leaf tissue creating a transparent skin, or "window," on the leaf surface. Older cloverworms eat holes in the leaves.

Cabbage looper: These caterpillars are light to dark green, with lighter colored stripes along the side and on the top, running the length of the body. When mature, the worms are 1 ½ inches long. These caterpillars have only two pairs of fleshy prolegs on the abdomen, plus the pair on the back tip. When moving, the caterpillars move by arching the middle of the body, or "looping." These worms feed on leaves in the interior and lower portion of the plant. As defoliation occurs, worms feed higher in the plant. Feeding injury is similar to the cloverworm.

Velvetbean caterpillar: This insect does not overwinter in the region; instead, moths migrate from Southern locations. These caterpillars have dark lines bordered by lighter colored, narrower lines running the length of the body. The background color ranges from a pale yellow-green to brown or black. These larvae have four pairs of fleshy prolegs to distinguish them from the cloverworm and the looper. Young velvetbean caterpillars feed on the underside of leaves in the upper portion of the plant. Older larvae consume the entire leaf, except for the leaf veins.

Thistle caterpillar: This insect is the larva of the butterfly known as the Painted Lady. This butterfly does not overwinter in the region, but migrates from Southern locations each spring. These caterpillars are brown to black in color with yellow stripes along each side of the body. They are covered with spiny hairs that give the caterpillar a prickly appearance. Full grown larvae are about 1 ½ inches long. The caterpillars feed on the leaves, webbing them together at the feeding site.

Alfalfa webworm: These larvae are 1 inch when full grown. They are greenish to nearly black with a light stripe that runs down the middle of the back. There are three dark spots, each with hairs, on the side of each segment. These larvae feed for about 3+ weeks. Infestations are characterized by light webbing over the leaves. Beneath the web is where the larvae feed, consuming the leaves. These larvae move very rapidly, forward or backward, when disturbed.

Threshold: Rather than using thresholds for individual defoliating insect species present in the field consider total leaf area lost as a threshold when defoliators are actively feeding: vegetative 50%, bloom 40%, bloom-pod fill 20% and pod fill-harvest 35%. An average infestation of 4 to 8 larvae per row foot typically caused 20-30% defoliation.

GRASSHOPPERS

In the Northern Plains, grasshopper egg hatch normally begins in late April to early May. Most grasshoppers emerge from eggs deposited in uncultivated ground. Soybean growers should expect to find grasshoppers feeding first along bean field margins adjacent to non-crop sites where the nymphs are hatching. Later infestations may develop when grasshopper adults migrate from harvested small grain fields. Grasshoppers will feed upon leaves and pods, chewing holes in them. A result of these migrations is soybean fields becoming sites for significant egg laying.

Threshold: The threatening rating is considered the action threshold for grasshoppers. For example, grasshopper control is advised whenever 50 or more small nymphs per square yard can be found in adjacent, non-crop areas, or when 30 or more nymphs per square yard can be found within the field. When 20 or more adults per square yard are found in field margins or 8 to 14 adults per square yard are occurring in the crop, treatment would be justified. Since it is difficult to estimate the number of

grasshoppers per square yard when population densities are high, pest managers can use four 180-degree sweeps with a 15-inch sweep net, which is equivalent to the number of adult (or nymph) grasshoppers per square yard.

	Nymphs per square yard		Adults per square yard	
Rating	Margin	Field	Margin	Field
Light	25-35	15-25	10-20	3-7
Threatening	50-75	30-45	21-40	8-14
Severe	100-150	60-90	41-80	15-28
Very Severe	200+	120+	80+	28+

Many of the grasshopper infestations in soybeans will be the heaviest on the field margins. Treating these areas may lessen the total numbers of grasshoppers successfully entering a field. Soybeans are most sensitive to defoliation during pod development (growth stages R4 to R6). During this time, plants can only tolerate up to 20% defoliation. Of greater concern would be direct feeding damage to pods and seeds. Grasshoppers are able to chew directly through the pod walls and damage seed directly. If more than 5% to 10% of the pods are injured by grasshoppers, an insecticide application would be recommended.

POTATO LEAFHOPPER

The adult is wedge-shaped and pale green in color. Adults are very active, jumping or flying when disturbed. Nymphs are wingless. Both adults and nymphs run backwards or sideways rapidly when disturbed. Nymphs feed on the underside of the leaf, usually completing their growth on the leaves near where they hatched. Large numbers of adults may appear early in the season, but their presence is dependent on migration from the eastern United States.

Soybeans with moderate to dense pubescence, or plant hairs, are tolerant to leafhopper infestations. The short plant hairs form a barrier that discourages leafhoppers from feeding and ovipositing eggs on plant tissue. When feeding does occur, damage by leafhoppers is referred to as hopper-burn. Foliage becomes dwarfed, crinkled and curled. Small triangular brown areas appear at the tips of leaves, gradually spreading around the entire leaf margin. Potential damage to soybeans by potato leafhopper is based on very limited research data. Damage would be more likely when drier growing conditions occur.

Threshold: The threshold for basing spray decisions is when an average of 5 leafhoppers (adults + nymphs) per plant are found in the vegetative stages, and 9 leafhoppers (adults + nymphs) per plant in early bloom stages. A treatment should be considered when visible injury symptoms are combined with large leafhopper populations.

SEED CORN MAGGOT

Seedcorn maggot attacks soybean seed, preventing sprouting or weakening the seedlings. The yellowish white maggot is found burrowing in the seed, emerging stem or the cotyledon leaves. Damage to the seedlings results in a condition called “snakeheads,” or plants without cotyledon leaves. The adult flies emerge in spring when soil temperatures reach 50° F. They deposit eggs in soil where there is abundant organic matter and decaying crop residue, or on the seed or seedling. Injury from seedcorn maggots is usually most severe during wet, cold springs and in fields with high organic matter soils. When cool, wet conditions occur during planting, the slow emergence of the seedling extends the period of time it is vulnerable to feeding by the maggot.

Threshold: When conditions are wet and cool, or when planting into high crop residue conditions, seed treatments provide the best defense against injury. For additional information on seed treatments, refer to page 7.

SOYBEAN APHID

The soybean aphid is light yellow with black cornicles (“tail-pipes”) and a pale colored cauda (tail projection). As with other aphids, the soybean aphid is small, about the size of a pinhead. Nymphs are smaller. Aphids suck fluid from plants. When infestations are large, infested leaves are wilted or curled. The aphids excrete honeydew, a sweet substance that accumulates on surfaces of lower leaves and promotes the growth of sooty mold. This aphid colonizes tender leaves and branches from seedling to blooming. Later, as the growing point slows, the aphids slow their reproductive rate, move down to the middle and lower part of the plant, and feed on the undersides of leaves. Toward the end of the season, the colonies begin to rapidly increase in number again. These increases are followed by a migration to the overwintering, alternate host, buckthorn.

Scouting: Currently, the guidelines for making soybean aphid treatment decisions are:

Begin scouting soybean fields at the V3 to V4 stage to determine if soybean aphids are present in fields. No treatment is recommended at this time and is discouraged so insecticides do not reduce the presence of predators and parasites. The critical growth stages for making most soybean aphid treatment decisions in North Dakota appear to be the late vegetative to early reproductive stages (V*n* to R3). Assessing aphid populations at this time is critical. Typically aphid treatments occur from mid-July to mid-August.

Economic Threshold: R1 (beginning of flowering) to R5 (beginning seed) = 250 aphids/plant when populations are actively increasing in 80% of field

R6 (full seed) = No treatment necessary. Research trials throughout the north central states have not demonstrated a yield benefit to treating soybean for soybean aphid management at the R6 and later stages.

Aphids Resistant to Pyrethroid Insecticide.

Pyrethroid resistance was documented in North Dakota, Minnesota, and South Dakota in 2017. In Figure 1, highlighted counties show where pyrethroid performance issues occurred for soybean aphid management in 2017. A total of nine counties were reported in eastern ND. Soybean aphids were collected from six soybean fields with reported pyrethroid failure, and these aphids were evaluated for bifenthrin and lambda-cyhalothrin resistance using the glass vial bioassay. Aphid populations from Casselton, Hope, Emerado, Lodema and Osnabrock had significantly less mortality than the laboratory population for bifenthrin; and Grafton (2 fields), Lodema and Osnabrock for lambda-cyhalothrin. These populations are considered resistant in ND soybean fields.

To reduce development of insecticide resistance in soybean aphids, Extension Entomology recommends:

- Scout fields regularly.
- Use the Economic Threshold to aid in decision-making, prevent unnecessary insecticide applications and conserve natural enemies.
- Rotate mode of action (or insecticide class) if more than one applications is necessary in a season.
- Do not use the same mode of action (or insecticide class) repeatedly year after year.
- Avoid using the lowest rate of insecticide on label. Use high rates.
- Do not use premix insecticides containing two insecticides of the same or two different modes of action, because premixes have lower amounts of active ingredient per insecticide.

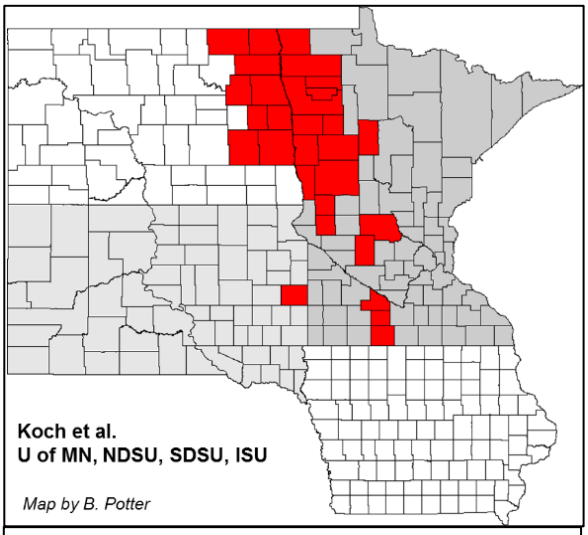


Figure 1. Field reports of pyrethroid failure for control of soybean aphid in 2017.

SPIDER MITES

Mites are small and magnification is required to see them. A quick sampling procedure to determine whether mites are present is to hold a piece of white paper below leaves then slap them to dislodge the mites. Or, pulling plants and examining the underside of the leaves from the bottom of plants upwards. The mites appear as tiny dust specks; however, they will move after being knocked off the leaf. Feeding damage by mites first appears as small yellow spots ("stippling"). As feeding activity increases, leaves become yellow, bronzed or brown, and eventually shed from the plant. Be sure to scout during full pod (R4) through beginning seed (R5) stages since these crop stages are the most important contributors to yield.

Mites usually become a problem when hot, dry weather occurs. Infestations typically are first noted near field edges. These environmental conditions stress the plant, whether mites are present or not. If conditions continue, treating for mites is no guarantee plants will recover. In addition, products labeled for mite control often do not give adequate control and the population of mites may rebound quickly to pretreatment levels or higher. When rain and humidity are present, natural reductions in mite populations occur due to infection by a fungal pathogen. Conditions that are good for the development of the pathogen are temperatures cooler than 85º F, with at least 90% R.H. for 12 to 24 hours.

Threshold: Deciding whether to treat is difficult. There is no specific threshold that has been developed for two-spotted spider mite in soybeans. Sample plants at least 100 feet into the field and walk in a “U” pattern sampling two plants per location at 20 different locations. Assess mite damage using the following scale from the University of Minnesota:

0 - No spider mites or injury observed.

1 - Minor stippling on lower leaves, no premature yellowing observed.

2 - Stippling common on lower leaves, small areas or scattered plants with yellowing.

3 - Heavy stippling on lower leaves with some stippling progressing into middle canopy. Mites present in middle canopy with scattered colonies in upper canopy. Lower leaf yellowing common. Small areas with lower leaf loss

(Spray Threshold)

4 - Lower leaf yellowing readily apparent. Leaf drop common. Stippling, webbing and mites common in middle canopy. Mites and minor stippling present in upper canopy.

(Economic Loss)

5 - Lower leaf loss common, yellowing or browning moving up plant into middle canopy, stippling and distortion of upper leaves common. Mites present in high levels in middle and lower canopy.

Remember to use an organophosphate insecticide (e.g. Dimethoate) over a pyrethroid insecticide to avoid flaring mite populations. However, the active ingredient, bifenthrin (pyrethroid) does not flare mite populations. Reasons for the increase in mite populations from some pyethroids include: disruption of the natural enemies that control spider mites (predatory mites); increased movement of mites out of fields, and increased reproductive rates of female mites. Early detection facilitates timely and effective rescue treatments. Current insecticides for corn provide short-term protection, maybe 7 days, from the pest. Fields will need to be re-monitored continually for resurging populations. The efficacy of an insecticide can be improved significantly with sufficient coverage >18 GPA of water by ground and 3-5 GPA by air and application at high pressure to penetrate foliage. For insecticide resistance management of mites, do not apply the same class of insecticide (or mode of action) more than twice and alternate the class of the insecticides (or mode of action) to prevent buildup of resistant mite strains.

WIREWORMS

To decide whether wireworms are a potential problem, refer to the discussion in the corn insects section. For commercial seed treatment, use decisions must be made at time of seed purchase. Please the seed treatment section in the introduction for more information.

INSECTICIDES REGISTERED FOR USE IN SOYBEAN

INSECTICIDE	PRODUCT PER ACRE	PHI	Armyworms	Bean Leaf Beetle	Cutworms	Foliage Caterpillars	Grasshoppers	Potato Leafhopper	Seed Corn Maggot	Soybean Aphid	Spider Mites	Wireworms
abamectin Agri-Mek SC *RUP*	1.75 - 3.5 fl oz	28 days for seed									●	
abamectin + thiamethoxam + fungicides Avicta 500 FS *RUP*	**Commercial Seed Treatment Only** Consult individual product labels for rates	Consult individual product labels										●
abamectin + thiamethoxam + fungicides Avicta Complete Beans 500 *RUP*	**Commercial Seed Treatment Only** 6.2 fl oz per cwt 2.89 fl oz per 140,000 seed	Consult product label		●								●
acephate Acephate 90 PRILL Acephate 90WDG Acephate 97 Acephate 97UP	0.28 - 1.1 lbs 0.28 - 1.1 lbs 0.25 - 1 lb 0.25 - 1 lb	14 days Do not graze or harvest for hay or forage	●	●		●	●	●		●		
afidopyropen Sefina	3 fl oz	7 days Do not feed or graze soybean hay or forage								●		
alpha-cypermethrin Fastac CS Fastac EC *RUP*	1.3 - 3.8 fl oz	21 days Do not graze or harvest for hay or forage	●	●	●	●	●	●		●		
Bacillus thuringiensis Biobit HP Dipel DF Dipel ES Xentari DF	0.5 -2 lbs 0.25 - 2 lbs 1 - 4 pts 0.5 - 2 lbs	None	‡			‡						
beta-cyfluthrin Baythroid XL *RUP*	0.8 - 2.8 fl oz	21 days for seed 15 days for hay and green forage	‡	●	●	●	●	●		●		
beta-cyfluthrin + imidacloprid Leverage 360 *RUP*	2.4 - 2.8 fl oz	21 days for seed 15 days for hay and green forage	‡	●	●	●	●	●		●		
bifenthrin Bifender FC *RUP*	Broadcast to soil (armyworm and cutworm): 2.9 – 5.9 fl oz At-plant: 0.17 - 0.34 fl oz per 1000 linear feet PPI, PRE: 2.9 - 4.6 fl oz	None listed	●		●				●			●

Soybean

INSECTICIDE	PRODUCT PER ACRE	PHI	Armyworms	Bean Leaf Beetle	Cutworms	Foliage Caterpillars	Grasshoppers	Potato Leafhopper	Seed Corn Maggot	Soybean Aphid	Spider Mites	Wireworms
bifenthrin Capture LFR Sniper LFR *RUP*	At-plant: 0.2 - 0.39 fl oz per 1,000 linear feet PPI: 4 - 5.3 fl oz	None	●		●				●			●
bifenthrin Capture LFR Ethos XB Sniper LFR *RUP*	PRE: 3.4 fl oz	None	●		●							
bifenthrin Ethos XB *RUP*	At-plant: 0.2 - 0.49 fl oz per 1,000 linear feet	None	●		●				●			●
bifenthrin Bifender FC Bifen 2 AG Gold Bifenture EC Brigade 2EC Discipline 2EC Fanfare 2EC Sniper Sniper Helios Tundra EC *RUP*	Foliar Applications: 2.4 - 7.4 fl oz 2.1 - 6.4 fl oz 2.1 - 6.4 fl oz 2.1 - 6.4 fl oz 2.1 - 6.4 fl oz 2.1 - 6.4 fl oz 2.1 - 6.4 fl oz 2.1 - 6.4 fl oz 2.1 - 6.4 fl oz 2.1 - 6.4 fl oz	18 days	●	●	●	●	●	●		●	●	
bifenthrin + chlorpyrifos Tundra Supreme *RUP*	5.6 – 16.8 fl oz	28 days Do not graze or harvest for hay, straw, forage or feed	●	●	●	●	●	●		●	●	
bifenthrin + imidacloprid Brigadier *RUP*	3.8 - 6.1 fl oz	45 days for feeding dry vines 18 days for feeding green vines	●	●	●	●	●	●		●		
bifenthrin + imidacloprid Skyraider Swagger *RUP*	2.1 - 6 fl oz 7.6 - 12.2 fl oz	18 days	●	●	●	●	●	●		●	●	
bifenthrin + zeta-cypermethrin Hero *RUP*	2.6 - 10.3 fl oz	21 days Do not graze or harvest for hay, straw, forage or feed	●	●	●	●	●	●		●	●	
carbaryl Sevin 4F Sevin XLR Plus	0.5 - 1.5 qts 0.5 - 1.5 qts	21 days for seed 14 days for grazing or harvest for forage	●	●	●	●		●				
chlorantraniliprole Coragen Prevathon	3.5 - 5 fl oz 14 - 20 fl oz	1 day	●									
chlorantraniliprole + lambda-cyhalothrin Besiege *RUP*	5 - 10 fl oz	30 days	●	●	●	●	●	●		●		
chlorpyrifos Lorsban 15G	8 oz per 1,000 row-feet	28 days			●							

Soybean

INSECTICIDE	PRODUCT PER ACRE	PHI	Armyworms	Bean Leaf Beetle	Cutworms	Foliage Caterpillars	Grasshoppers	Potato Leafhopper	Seed Corn Maggot	Soybean Aphid	Spider Mites	Wireworms
chlorpyrifos Chlorpyrifos 4E AG Govern 4E Hatchet Lorsban 4E Lorsban Advanced Nufos 4E Vulcan Warhawk Whirlwind Yuma 4E *RUP*	At Plant[1]: 1 - 2 pts Foliar Application 0.5 - 2 pts	28 days for seed Do not graze or harvest for hay, straw, forage or feed	●	●	●	●	●	●		●	●	
chlorpyrifos + bifenthrin Match-Up *RUP*	5.5 - 16.4 fl oz	28 days	●	●	●	●	●	●		●	●	
chlorpyrifos + lambda-cyhalothrin Cobalt Advanced *RUP*	At Plant[1]: 11 - 38 fl oz Foliar Application: 6 - 38 fl oz	30 days for seed Do not graze or harvest for hay, straw, forage or feed	●	●	●	●	●	●		●	●	
chlorpyrifos + zeta-cypermethrin Stallion *RUP*	3.75 - 11.75 fl oz	28 days for seed Do not graze or harvest for hay, straw, forage or feed	●	●	●	●	●	●		●		
clothianidin Belay	3 - 6 fl oz	21 days for seed Do not graze or harvest for hay or forage		●				●		●		
clothianidin Intego Suite Soybeans	**Commercial Seed Treatment Only** 3.37 fl oz per cwt	Do not graze or feed soybean forage and hay to livestock		●				●	●	*		●
clothianidin + *Bacillus firmus* Poncho Votivo	**Commercial Seed Treatment Only** 0.13 mg ai per seed	Do not graze or feed forage and hay		●				●	●	*		●
clothianidin + fungicides Inovate System (NipsIt Inside + fungicides)	Consult individual product labels for rates	Consult individual product labesl		●				●	●	*		●
cyantraniliprole Fortenza	**Commercial Seed Treatment Only** 0.038 - 0.076 mg ai per seed			●								●
cyfluthrin Tombstone Tombstone Helios *RUP*	0.8 - 2.8 fl oz	45 days for seed and feeding of dry vines 15 days for green forage	‡	●	●	●	●	●		●		
deltamethrin Batallion 0.2EC Delta Gold *RUP*	7.7 - 14.1 fl oz 9.5 - 11.5 fl oz for soybean aphid 1 - 2.4 fl oz	21 days for seed Do not graze or harvest for hay, straw, forage or feed	‡	●	●	●	●	●		●		
diflubenzuron Dimilin 2L *RUP*	2 - 4 fl oz	21 days	‡			‡	‡					
dimethoate Dimate 4E Dimethoate 400 Dimethoate 4E Dimethoate 4EC	1 pt	21 days for seed 5 days for for grazing and feed		●			●	●			●	

Soybean

INSECTICIDE	PRODUCT PER ACRE	PHI	Armyworms	Bean Leaf Beetle	Cutworms	Foliage Caterpillars	Grasshoppers	Potato Leafhopper	Seed Corn Maggot	Soybean Aphid	Spider Mites	Wireworms
esfenvalerate Asana XL *RUP*	2.9 - 9.6 fl oz	21 days for seed Do not graze or harvest for hay or forage		●	●	●	●	●		●		
etoxazole Zeal SC	2 - 6 fl oz	Do not apply after R5 Do not make more than one application per season Do not graze treated soybean fields or feed treated forage or hay to livestock									●	
flupyradifurone Sivanto Prime	7 - 10.5 fl oz	7 days for forage, leaves, vines and hay 21 days for seed						●		●		
gamma-cyhalothrin Declare *RUP*	0.77 - 1.54 fl oz	30 days for seed Do not graze or harvest for hay or forage	●	●	●	●	●	●		●	†	
imidacloprid Attendant 480FS Attendant 600 Dyna-Shield Imidacloprid 5 Gaucho 600 Senator 600	**Commercial Seed Treatment Only** 2 - 4 fl oz per cwt 1.6 - 3.2 fl oz per cwt	Do not graze or feed forage or hay		●					●			●
imidacloprid Enhance AW	5 oz per cwt	Do not graze or feed forage or hay		●					●	*		●
imidacloprid ADAMA Alias 4F AmTide Imidacloprid 2F Admire Pro Wrangler Nuprid 2SC Nuprid 4F Max Prey 1.6 Sherpa	0.75 fl oz 1.3 fl oz 1.5 fl oz 1.5 fl oz 3.75 fl oz 3 fl oz 1.5 fl oz 3.75 fl oz 3.75 fl oz	7 days		●				●		●		
indoxacarb Steward EC	4.6 - 11.3 fl oz	21 days for seed Do not graze or feed	●			●						
lambda-cyhalothrin Grizzly Too Kendo Lambda-Cy EC LambdaStar Lambda-T Lamcap Nufarm Lambda-Cyhalothrin 1EC Paradigm VC Province Silencer Silencer VXN Warrior II *RUP*	0.96 - 1.92 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 0.96 - 1.92 fl oz	30 days for seed Do not graze or harvest for hay, straw, forage or feed	●	●	●	●	●	●		●	†	
lambda-cyhalothrin + thiamethoxam Endigo ZC *RUP*	3.5 - 4.5 fl oz	30 days for seed	●	●	●	●	●	●		●	†	

Soybean

INSECTICIDE	PRODUCT PER ACRE	PHI	Armyworms	Bean Leaf Beetle	Cutworms	Foliage Caterpillars	Grasshoppers	Potato Leafhopper	Seed Corn Maggot	Soybean Aphid	Spider Mites	Wireworms
		Do not graze or harvest for hay, straw, forage or feed										
methomyl Lannate LV *RUP*	0.4 - 1.5 pts	14 days for seed 12 days for hay 3 days for forage	●	●		●				●		
methoxyfenozide Intrepid 2F	4 - 8 fl oz	14 days for seed 7 days for hay and forage	●			●						
permethrin Ambush 25W Ambush Arctic 3.2EC Permethrin Permethrin 3.2EC Perm-UP 3.2 EC *RUP*	3.2 - 6.4 oz 3.2 - 6.4 fl oz 2 - 4 fl oz 2 - 4 fl oz 2 - 4 fl oz 2 - 4 fl oz	60 days for seed Do not graze or harvest for hay or forage		●	●	●		●				
permethrin Arctic 3.2EC *RUP*	4 - 8 fl oz (2ee recommendation for soybean aphid)	60 days for seed Do not graze or harvest for hay or forage								●		
permethrin Kernel Guard Supreme	Planter Box: 1.5 oz per 50 lbs of seed	45 days for grazing or feeding							●			●
phorate Thimet 20G Lock n Load Thimet 20G SmartBox *RUP*	9 oz per 1,000 row-feet	Do not place granules in direct contact with seed Do not graze or feed foliage						●	●			
spinetoram Radiant SC	2 - 4 fl oz	28 days	‡			‡						
spinosad Blackhawk Entrust Tracer	1.1 - 2.2 oz 0.75 - 1.25 oz 1 - 2 fl oz	28 days for seed Do not graze or harvest for hay or forage	‡			‡						
sulfoxaflor Transform WG	0.75 - 1 oz	7 days								●		
thiamethoxam Cruiser 5FS	1.28 fl oz per cwt	None		●				●	●	*		●
thiamethoxam Clariva Elite Beans Cruiser Maxx Cruiser Maxx Vibrance Upshot Soybeans Warden CX	5.6 fl oz per cwt or 2.6 fl oz per 140,000 seeds 2.95 fl oz per cwt or 1.38 fl oz per 140,000 seeds 3.22 fl oz per cwt or 1.5 fl oz per 140,000 seeds 2.95 fl oz per cwt or 1.38 fl oz per 140,000 seeds 3.38 fl oz per cwt or 1.58 fl oz per 140,000 seeds	Clariva Elite Beans, Cruiser Maxx Vibrance and Warden CX: Do not graze or feed livestock on treated areas for 45 days after planting		●				●	●	*		●
zeta-cypermethrin Mustang Maxx *RUP*	1.28 - 4 fl oz	21 days for seed Do not graze or harvest for hay, straw, forage or feed	●	●	●	●	●	●		●		

RUP = Restricted Use Pesticide
[1] = At-plant applications of chlorpyrifos products for control of cutworm spp. only
* = Seed treatments may provide protection against early-season soybean aphids, but may not against later season aphids
† = Suppression only
‡ = Control of first and second instar larvae and nymphs only

SUGARBEET INSECTS

Other sugarbeet insect resources:

Publications: A1698 Sugarbeet Production Guide (2019)
E1273 Leaf-feeding Weevil in Sugarbeet (2016)
Sugarbeet Research and Extension Reports (http://www.sbreb.org/research/research.htm)
E830 The Armyworm and the Army Cutworm (revised 2018)

Calendar of Potential Insect Pest Activity in Red River Valley Sugarbeet Fields														
April	May				June				July				August	
Flea Beetles														
	Springtails													
	White Grubs													
	Wireworms													
			Cutworms - Dingy, Dark-sided,											
				Beet Webworm - adults										
					Beet Webworm - larvae									
				Sugarbeet Root Maggot - adults										
					Sugarbeet Root Maggot - larvae									
												Tarnished Plant (*Lygus*) Bugs		
												Cutworms - Black and Variegated		

BEET WEBWORM

Beet webworms rarely occur in significant numbers in Red River Valley sugarbeet fields. Larvae are slender caterpillars and are very active when disturbed. Early-stage larvae are dark green. Older larvae are olive green. They have a dark band running down the center of their back, and it is flanked on each side by two light-colored stripes. Full-grown larvae can be up to 1½ inches long. Adults are mottled tan and brown moths with smoky grayish wing margins. The moths first appear in late May and early June. Larvae usually cause problems during the first 3 weeks of June. A second brood is also possible during late August and September.

Threshold: Insecticide treatment is recommended if 1 to 2 webworms are present on 50% to 75% of sampled leaves.

CUTWORMS

Darksided and Redbacked cutworms are the most common cutworm pests of sugarbeet in the Red River Valley. Eggs of both species hatch into larvae during late May and early June. Early detection of injury is essential to good control. Fields should frequently be checked for wilting or dead plants during early spring. Cutworms can be found within 2 inches of the soil surface near bases of wilting plants. Most feeding occurs at night. Young plants are often cut off near ground level. During periods of dry weather, larvae feed just below the soil surface as they move along the row. They feed above the soil surface if soil is excessively moist.

It is desirable to apply insecticides during late afternoon. This maximizes the amount of insecticide material present during the first nighttime hours following application, which is when larvae are often most active. Applications may be repeated as necessary during peak cutworm feeding. Liquid formulations generally provide better control of cutworms, especially during very dry periods. If severe crusting is evident in the field, the crust should be broken up before or during the insecticide application. In late July and August of 2001, variegated and black cutworm infestations damaged several sugarbeet fields. These insects migrate into our region as moths during the spring and are capable of multiple generations within a single growing season. Variegated cutworm larvae have a distinctive row of pale yellow spots down the middle of their backs. They are a climbing cutworm species that primarily feeds in the plant canopy during evening hours. Because variegated cutworms feed above ground, they can be effectively managed with foliar rescue insecticide applications. Late-season infestations of black cutworms often feed more than 2 inches below ground. Therefore, late-season control of this species can be difficult and is improbable to achieve.

Threshold: Cutworm control in young beets is suggested when 4 to 5% cutting of seedlings is observed. Control may be justified for late-season infestations of 3 to 5 larvae per square foot if they are feeding near or above the soil surface.

FLEA BEETLES

All flea beetle adults are tiny, oval-shaped, shell-winged insects with enlarged hind legs. The flea beetles most frequently found feeding on beets are shiny black in color and about 1/8 inch in length. When approached or disturbed, they readily jump to escape. Flea beetles overwinter as adults and emerge in late April and May. They feed first on weeds such as winter annuals, and move to field crops as weed hosts are depleted and crop seedlings begin emerging. Foliar feeding injury from flea beetles initially consists of small, rounded holes, and gives leaves a shot-hole appearance. Severe shot-holing damage can result in stunting, wilting, and even death of seedling plants. Plant responses will be most dramatic during the seedling stage and in periods of hot and dry weather.

Threshold: Treatment is usually justified if flea beetles threaten to reduce sugarbeet plant stands to below 35,000 plants/acre.

GRASSHOPPERS

In the Northern Plains, grasshopper egg hatch normally begins in late April to early May. Most grasshoppers emerge from eggs deposited in uncultivated ground. Sugarbeet growers should expect to find grasshopper feeding first along field margins adjacent to these sites. Beets in fields that follow late-season crops may have hatching throughout the field and should be monitored carefully if adults deposited eggs in the field during the previous fall. Later infestations can develop when grasshopper adults migrate from harvested small grain fields.

Threshold: Grasshopper control is advised whenever 20 or more adults per square yard are found in field margins or 8 to 14 adults per square yard are occurring in the crop. (For more information on infestation ratings, see the discussion under Grasshoppers in Small Grain Insects)

LYGUS BUG (TARNISHED PLANT BUG)

Tarnished plant bugs, commonly referred to as “Lygus bugs”, have caused late-season injury to Red River Valley sugarbeets since 1998. Most feeding injury appears on new leaves and stems emerging from the sugarbeet plant crown. Feeding symptoms include curling and wilting of leaves, feeding scars on leaf petioles, seepage of a black exudate from petioles of young leaves, and blackening of the new growth near the center of the crown. Two to three generations of Lygus bugs can develop during the growing season, especially if extended periods of unseasonably warm weather prevail during early spring and summer. Populations usually build up in other host plant habitats (e.g., alfalfa, canola, small-seeded broadleaf weeds), then adults migrate to beets in late-July through August. Lygus bugs are sporadic pests in this region and their biological profile is not understood well enough to anticipate when or where future problems could arise.

Threshold: Treatment with an insecticide may be justified if an infestation **exceeds** 1 Lygus bug per plant (adults and nymphs combined) and if the crop is at least three weeks from harvest. Careful consideration of insecticide pre-harvest intervals may be a critical factor in choosing an insecticide, because Lygus bugs typically infest sugarbeet late in the growing season (i.e., late-July through August). A number of insecticides approved for use on sugarbeets have activity for controlling Lygus bugs; however, the species that typically attacks Red River Valley sugarbeet (*Lygus lineolaris*, the tarnished plant bug) is not listed as a target pest in the *sugarbeet* portion of those labels**. Examples include Asana, Sevin and Lannate SP. It is legal to apply an insecticide if it is labeled for use in the crop**; however, if the target pest is not listed for that crop, effective control is not implied by the manufacturer and growers who choose to use the product assume their own liability for any unsatisfactory performance.

SPRINGTAILS

Springtails that damage RRV sugarbeet fields are tiny (1/32 to 3/32 inch long), wingless, white- to cream-colored insects with fleshy, forward-pointed antennae. They spend their entire life below the soil surface, and are most harmful to seedlings. Plant injury ranges from a few brown feeding punctures to extensive root scarring, severed tap roots, and seedling mortality. Field symptoms include wilted plants and plant stand losses, usually in irregular-shaped patches ranging in size of 0.5 to ten acres. *Fine-textured* (i.e., clay or silty clay) *soils* with *high organic matter content* are conducive to springtail problems. *Early-planted fields,* especially *where soils remain cool and wet during early spring*, can be especially vulnerable to attack. Field history is a good indicator of risk because springtails do not migrate from one field to another. Insecticides registered for use in sugarbeet against other soil-dwelling pests may be used for springtail control; however, manufacturers are not legally bound to guarantee acceptable control if springtail control is not listed on the product label.

NDSU research on springtail management suggests the following:

Counter 20G provides good springtail control if applied at rates of 0.9 to 1.5 lb AI (4.5 to 7.5 lb product) per acre.

Cruiser 5FS, NipsIt Inside, and Poncho Beta insecticidal seed treatments also provide good springtail control**.

Mustang Maxx has provided unsatisfactory control in some cases. It performs best when applied:

1. directly in-furrow at planting using conventional nozzles (not microtubes)
2. at full rate of 4 oz of product per acre, and
3. tank-mixed with strained 10-34-0 starter fertilizer at a ratio of 60:1 (fertilizer to insecticide).

*Lorsban 15G and other chlorpyrifos-based granular products do not provide adequate protection from springtail injury. Do not attempt to apply a chlorpyrifos-containing product directly in-furrow with seed, as phytotoxicity from these products can result in plant stand and yield loss.

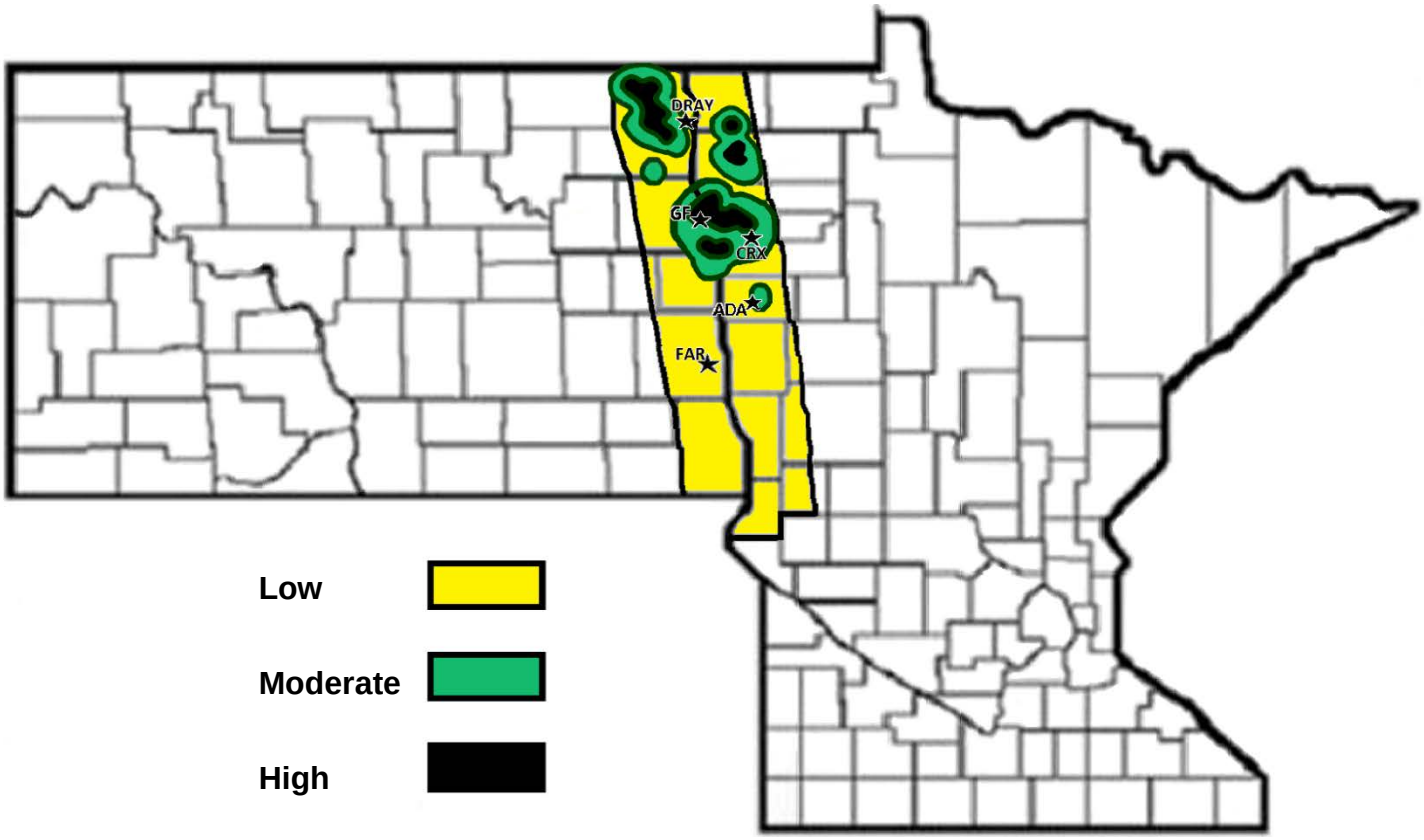
**Unsatisfactory springtail control from some insecticidal seed treatments has been reported in the MonDak growing area. Growers in affected areas should consider either using a granular insecticide such as Counter 20G or combining a seed treatment insecticide with an at-plant application of Mustang Maxx at the maximum labeled rate of 4 oz product per acre.

SUGARBEET ROOT MAGGOT (SBRM)

This insect overwinters in soil at 6 to 12 inches below the surface as a mature larva in fields that had been planted to sugarbeet during the previous growing season. In late April and early May, overwintered larvae move up to within 3 inches of the soil surface to pupate. In the Red River Valley, fly emergence generally begins in late May and continues for a period of 4 to 6 weeks. Following emergence, flies move to current-year beet fields and deposit most eggs below the soil surface near or on the bases of beet plants. Egg depth depends on soil moisture (i.e., eggs are deposited deeper in dry soils). Plants in earlier-seeded (April to early May) fields are usually more vigorous and able to tolerate more injury than smaller plants in later-planted fields. Fields planted in areas with established SBRM populations should be protected at planting-time by using a soil insecticide or insecticidal seed treatment. If dry conditions prevail following use of an at-plant granular insecticide, a postemergence insecticide application may be needed. Additive protection may also be needed if an insecticidal seed treatment was used for at-plant protection in areas where moderate to high root maggot infestations are expected. Producers should consider the following to determine if a postemergence insecticide is warranted: ***soil moisture*** - good soil moisture from spring rains should enhance planting-time insecticide performance – extreme rainfall events (1 to 3 inches within first 24 hours or at least 6 inches if received in 1 or 2 rainfall events within 1 week after planting) may cause movement of the insecticide from the treated target zone; ***sugarbeet size*** - plants that have 10 to 14 true leaves at peak activity (early- to mid-June) can tolerate moderate levels of feeding injury; ***population level*** - use sticky-stake traps to monitor for development of damaging population levels.

2020 Sugarbeet Root Maggot Population Forecast

The 2020 sugarbeet root maggot (SBRM) forecast map for the Red River Valley (RRV) is shown in the figure below. The 2019 growing season marked the third consecutive year of significant increases in fly activity and greater-than-expected root injury at several RRV locations. This suggest that root maggot infestations in 2020 will generally be higher than in previous years. Areas at highest risk of damaging SBRM infestations include rural Auburn, Bathgate, Cavalier, Crystal, Glasston, Grand Forks, Merrifield, St. Thomas, Thompson, and Walhala, ND, as well as Argyle, Crookston, Donaldson, East Grand Forks, Eldred, and Stephen, MN. Moderate risk is expected in areas bordering high-risk zones, as well as fields near Drayton, Buxton, Forest River, Hamilton, Nash, Oakwood, and Reynolds, ND, and Ada, Crookston, Eldred, and Fisher, MN. The remainder of the area is at lower risk. Proximity to previous-year beet fields where SBRM populations were high and/or control was unsatisfactory can increase risk. Sugarbeet fields near those where high fly activity occurred in 2019 should be closely monitored in 2020. Growers in high-risk areas should use an aggressive form of at-plant insecticide treatment (i.e., granular insecticide) and expect the need for a postemergence rescue insecticide (i.e., banded granules or peak-fly spray). Those in moderate-risk areas using insecticidal seed treatments for at-plant protection should monitor fly activity levels closely in their area, and be ready to apply additive protection if justified. Any grower in an area with a history of SBRM problems should pay close attention to fly activity levels in late-May through June to decide if postemergence treatment is needed. NDSU Entomology will continue to inform growers regarding SBRM activity levels and hot spots each year through radio reports, the NDSU "Crop & Pest Report", and notification of sugar cooperative agricultural staff when appropriate. Root maggot fly counts for the current growing season and those from previous years can be viewed at: http://www.ndsu.edu/entomology/people/faculty/boetel/flycounts/.



Anticipated risk of damaging sugarbeet root maggot infestations in the Red River Valley.

SUGARBEET ROOT APHID (SBRA)

Sugarbeet root aphids are tiny, yellowish- to lime/olive-green insects that occur in both winged and wingless forms. SBRA infestations occurred in all sugarbeet-producing counties of the Red River Valley in 2012 and 2013, and resulted in significant economic loss for some growers. Although the SBRA is a relatively infrequent pest in the Valley, it is most likely to be problematic in warm, dry growing seasons that follow a mild winter. The direct injury caused by this pest in the field results from aphids feeding by using piercing/sucking mouthparts. In addition to causing major tonnage and sucrose concentration losses, NDSU research has shown that roots severely injured by these pests continue to respire, lose additional sucrose, and even rot while in postharvest storage. Symptoms of root aphid infestation include plant wilting, leaf yellowing, premature decline (e.g., yellowing and necrosis) of older leaf petioles, and the presence aphid colonies with a whitish-colored moldy appearing waxy material along the root surface and associated soil. Resistant varieties are the best line of defense for managing SBRA. Research indicates that postemergence insecticide applications will only provide SBRA suppression. There is no evidence that insecticidal seed treatments will provide effective SBRA control.

WIREWORMS

Wireworms are smooth, somewhat hard-bodied larvae that vary in length from 1/2 to 1½ inch long; however, they are most damaging when they are about 1/2 to 3/4 inch in length. Their color can range from yellowish-white to a bright or deep copper color. Wireworms feed on a wide variety of crops and weeds, and are generally difficult to detect and control. They tend to be more prevalent in light-textured soils or in soil that has not been in crop production for several years. Fields that had grassy weed escapes during the preceding season are also at risk. Frequent tillage can help reduce wireworm problems.

Threshold: Currently, there is no established threshold for wireworms in sugarbeet. Several insecticides labeled for sugarbeet root maggot control can provide adequate protection from wireworm injury (see list below). Insecticidal seed treatments also can provide protection from wireworm injury. Check with your company field representatives before treating sugarbeet seed with an insecticide. Refer to product labels for more information. Please the seed treatment section in the introduction for more information.

Insecticides Registered for Use in Sugarbeet

INSECTICIDE	PRODUCT PER ACRE	PHI	Beet Webworm	Cutworms	Flea Beetles	Grasshoppers	Lygus Bugs	Springtails	Sugar Beet Root Maggot Adults	Sugar Beet Root Maggot Larvae	Wireworms
alpha-cypermethrin Fastac CS Fastac EC *RUP*	2.2 - 3.8 fl oz	50 days Do not graze or harvest treated beet tops for livestock feed		●	●	●					
carbaryl Sevin 4F Sevin XLR Plus	1 - 1.5 qts 1 - 1.5 qts	28 days for roots or forage	●	●	●						
chlorpyrifos Lorsban 15G Lorsban 15G SmartBox	At-Plant T-Band: 4.5 - 9 oz per 1,000 row-feet **Do not apply granules in direct contact with seed**	30 days		●						●	†
chlorpyrifos Lorsban 15G Lorsban 15G SmartBox	Postemergence Band: 6.5 - 9 oz per 1,000 row-feet **Do not apply granules in direct contact with seed**	30 days								●	
chlorpyrifos Chlorpyrifos 4E AG Govern 4E Lorsban 4E Lorsban Advanced Nufos 4E Warhawk Whirlwind Yuma 4E *RUP*	Broadcast Foliar: 0.5 - 2 pts	30 days for roots, grazing or harvest of tops for feed	●	●	●	●	●		●		

INSECTICIDE	PRODUCT PER ACRE	PHI	Beet Webworm	Cutworms	Flea Beetles	Grasshoppers	Lygus Bugs	Springtails	Sugar Beet Root Maggot Adults	Sugar Beet Root Maggot Larvae	Wireworms
chlorpyrifos Chlorpyrifos 4E AG Govern 4E Lorsban 4E Lorsban Advanced Nufos 4E Warhawk Whirlwind Yuma 4E *RUP*	Banded Foliar: 0.67 - 2 pts	30 days for roots, grazing or harvest of tops for feed	●	●	●					●	
clothianidin NipsIt INSIDE	3.4 fl oz per 100,000 seed unit	None			●			●		●	●
clothianidin NipsIt SUITE Sugar Beets NipsIt INSIDE Insecticide	**Commercial Seed Treatment Only**	Consult individual registered product labels (see Valent website for more information)			●			●		●	●
clothianidin + beta-cyfluthrin Poncho Beta	**Commercial Seed Treatment Only** 5.07 fl oz per 100,000 seed unit	None			●			●		●	●
esfenvalerate Asana XL *RUP*	At Plant: 0.45 fl oz per 1,000 row-feet	21 days		●							
esfenvalerate Asana XL *RUP*	Foliar Application: 5.8 - 9.6 fl oz	21 days	●	●	●	●			●		
imidacloprid Attendant 480FS Dyna-Shield Imidacloprid 5 Gaucho 600 Senator 600FS	**Commercial Seed Treatment Only** 3 - 6.3 fl oz per 100,000 seed unit 2.4 - 5 fl oz per 100,000 seed unit	None									●
methomyl Lannate LV Lannate SP *RUP*	0.25 - 1 lb	21 days for roots 30 days for tops	●	●	●						
naled Dibrom 8 Emulsive *RUP*	1 pt	2 days					●				
phorate Thimet 20G Lock 'n Load Thimet 20G SmartBox *RUP*	3.4 - 4.5 oz per 1,000 row-feet **Do not apply granules in direct contact with seed**	30 days								●	
spirotetramat Movento HL	2.25 - 4.5 fl oz Do not apply more than 9 fl oz per crop season	28 days Minimum interval between applications is 14 days							†	†	
terbufos Counter 20G Lock 'n Load	3 - 6 oz per 1,000 row feet	90 days for harvest of roots or harvest of tops for livestock feed		†				●		●	●

Sugarbeet

INSECTICIDE	PRODUCT PER ACRE	PHI	Beet Webworm	Cutworms	Flea Beetles	Grasshoppers	Lygus Bugs	Springtails	Sugar Beet Root Maggot Adults	Sugar Beet Root Maggot Larvae	Wireworms
Counter 20G SmartBox *RUP*	**Do not apply granules in direct contact with seed**										
thiamethoxam Cruiser 5FS	3.39 - 3.95 fl oz per 100,000 seed unit	None						●		●	●
thiamethoxam + fungicides Cruiser MAXX Sugar Beets	Consult individual product labels for rates	Consult individual product labels						●		●	●
zeta-cypermethrin Mustang Maxx *RUP*	At Plant: 4 fl oz Foliar: 2.24 - 4 fl oz	50 days for roots or tops		●					†	†	●

RUP = Restricted Use Pesticide
† = Suppression only

Sugarbeet

SUNFLOWER INSECTS

Publications	A1331	Sunflower Production (2014)
	E1457	IPM of Sunflower Insect Pests in the Northern Great Plains (2015)
	E823	Banded Sunflower Moth (2019)

BANDED SUNFLOWER MOTH

BSM begin to emerge from the soil about mid-July. Peak activity normally occurs about the last week of July or the first week of August. Moths fly from last year's field to the current year's field. At this time moths congregate around field margins. The moths move to fields during the bud stage, with a preference for the mid-bud stage. Eggs are laid on the back of the bud and the outside of the bracts. The newly hatched larvae move from these sites to the face of the flower and begin feeding on bracts and florets.
Two distinct and separate sampling procedures can be used to estimate the field damage potential from the banded sunflower moth. The first samples for eggs and the second samples for the adult (moth) stage.

Egg Sampling

The potential for banded sunflower moth damage is determined by counting eggs on the outer layer of floral bracts in the field. Because the eggs are very small a magnifier is needed to accurately count the small eggs. We recommend using a head-mounted 3.5X magnifier to leave both hands free for manipulating the bud being observed. Egg counts should be made when most of the plants in the field are at plant stage R3 (distinct bud elongated ¾ inch above the nearest leaf, yellow ray petals not visible). However, to avoid sampling bias, buds should be randomly selected without regard to plant stage. The egg sampling steps include: 1) Divide each side of the field into two sections, 2) Sample the center of each section at 20 feet into the filed from the field edge, 3) Randomly select five buds, 4) From each bud, randomly select six bracts from the outer whorl and count the eggs on each bract, and 5) Average the egg counts from the five buds and then map the average egg counts from each site to a diagram of the field. Next, calculate the economic injury level. The economic injury level (EIL) is the density or number of insects expected to cause damage that is equal to the cost of control. For Banded sunflower moth, EIL is the number of eggs per 6 bracts and considers treatment cost ($/acre), market price ($/lb), and plant population per acre.

$$\textbf{EIL} = \frac{\textbf{Treatment Cost (\$)}}{\textbf{Market Price (\$) x Plant Population x 0.00078}}$$

An **ED Calculator** is available from the North Dakota State University Department of Entomology Web site for automatically calculating the egg EIL and Economic Distance (http://www.ndsu.nodak.edu/entomology/ext.htm). The economic distance is the distance from the field margin that an economic infestation is present based on the egg density. Please obtain a copy of 2006 **Extension Bulletin E823 'Banded Sunflower Moth'** for complete details for determining the EIL, economic distance and timing of treatments.

Adult Moth Sampling during Day

Sampling sites should be at least 75 to 100 feet from the field margins. In monitoring a field, use the X pattern, counting moths on 20 plants per sampling site to obtain the total number of moths per 100 plants. Sampling should be conducted in the late bud stage (R3), usually during mid-July. If treatment is warranted, it should be applied at the R5.1 sunflower plant growth stage (when 10% of head area has disk flowers that are flowering or completed flowering). During the day (late morning to early afternoon) the moths remain quiet, resting on upper or lower surfaces of the leaves of sunflower plants. When disturbed, they flutter from plant to plant. When sampling for moths during day, the decision to treat or not is based on comparing the mean number of adult moths in the field to the EIL for moths. The EIL is the number of moths per head that will, if not managed, result in seed damage with a value equal to the cost of treatment. Use the following formula based on treatment costs, plant population and market price to determine the adult moth EIL for day sampling.

$$\underset{\textbf{(moths per 100 plants)}}{\textbf{EIL}} = \left(\frac{\textbf{(Treatment Cost (\$) / Market Price)}}{\textbf{Plant Population}} \right) \textbf{ x 582.9 }) \textbf{ - 0.7}$$

The constants in the formula simplify the calculation and include the amount of loss attributable to each banded sunflower moth larva produced per moth.

Chemical Control and Application Timing: Chemical treatment is directed at the larval stage of the banded sunflower moth which is the actual damaging stage. Once the decision to treat has been made, it is critical to correctly time the spray application to get maximum control. The best sunflower plant stage to treat is the R5.1 growth stage, or when pollen shed is just beginning. This is the time when most banded sunflower moth eggs have hatched and larvae are present, but before the head has seeds forming. At this time the larvae are beginning to feed on the disk flowers, are exposed on the head, and are susceptible to the insecticide treatment. On older plants where the seeds have started maturing, most larvae will be feeding within the seeds or under the protection of the florets and will be protected from the insecticide. By then, much of the feeding damage has already occurred. Application at an earlier growth stage may be warranted if monitoring reveals earlier than normal egg-laying activity. The **banded sunflower moth**, **seed weevil** and the **Lygus bug** have all impacted quality of **confection sunflowers** the past three to four seasons. It is recommended at this time, that **sunflowers grown for these markets be treated a minimum of two times**, once at early flowering and again 5 to 7 days later. With this type of program, a window of protection should be provided to minimize impact from all three of these seed-damaging insect pests.

CUTWORMS

Most damage by cutworms occurs when plants are in the early stage of development. Damage consists of young plants being chewed off slightly below or at ground level. Some cutworm feeding injury may occur on foliage. Cutworms primarily feed at night. When checking fields for cutworms during the day, dig down into soil an inch or two around recently damaged plants; and look for the gray to gray-brown larva.

Threshold: Treatment is warranted when one cutworm or more is found per square foot or there is a 25% to 30% stand reduction observed.

GRASSHOPPERS

In the Northern Plains, grasshopper egg hatch normally begins in late April to early May. Most grasshoppers emerge from eggs deposited in uncultivated ground. Sunflower growers should expect to find grasshopper feeding first along field margins adjacent to these sites. Later infestations may develop when grasshopper adults migrate from harvested small grain fields.

Threshold: The threatening rating is considered the action threshold for grasshoppers. For example, grasshopper control is advised whenever 50 or more small nymphs per square yard can be found in adjacent, non-crop areas, or when 30 or more nymphs per square yard can be found within the field. When 20 or more adults per square yard are found in field margins or 8 to 14 adults per square yard are occurring in the crop, treatment would be justified. Since it is difficult to estimate the number of grasshoppers per square yard when population densities are high, pest managers can use four 180-degree sweeps with a 15-inch sweep net, which is equivalent to the number of adult (or nymph) grasshoppers per square yard.

	Nymphs per square yard		**Adults per square yard**	
Rating	Margin	Field	Margin	Field
Light	25-35	15-25	10-20	3-7
Threatening	50-75	30-45	21-40	8-14
Severe	100-150	60-90	41-80	15-28
Very Severe	200+	120+	80+	28+

Many of the grasshopper infestations in sunflowers will be the heaviest on the field margins. Treating these areas may lessen the total numbers of grasshoppers successfully entering a field.

SUNFLOWER STEM BORER OR LONG-HORNED BEETLE

Adults appear in mid-June to early July in the southern Plains. Emergence continues through August with 50% emerged by mid-July in Texas. Eggs are laid 4-8 days after mating and eggs are deposited singly in leaf petioles. Approximately 50 eggs are laid per female with about one-third viable. Eggs hatch in 6-10 days. Larvae tunnel and feed in the petioles and stem pith and finally move to the base of the plant to overwinter. Larvae develop through 6 instars. In late summer, the mature larvae girdle the inside of the lower stalk or root crown, move below the girdle, and pack frass into the tunnels. Stalks often break at the point of girdling, leaving the larva protected in its frass packed tunnel during the winter. Larvae are cannibalistic and stalks usually harbor only a single larva even though several may have originally hatched in a stalk. There is one generation per year. Host plants include sunflower, soybean, ragweed, and cocklebur. Plant damage due to adult feeding appears to be insignificant, since the scars do not penetrate the cortex nor encircle the stalk. Larval feeding is apparent when stalks lodge at the point of the girdle, about 2.5 to 3.5 inches (7 to 9-cm) above the soil surface.

Scouting Method: None has been developed.

Threshold: None established.

Management: In the southern Plains, later planting dates and fall or winter tillage have reduced sunflower infestations by this pest. Perennial sunflower species are resistant to stalk infestation, indicating the possibility of breeding cultivars resistant to the long-horned sunflower stem girdler. Chemical treatments on soybean and sunflower are ineffective against larvae and were determined to be impractical against adults because of the extended emergence period. When larvae are present in the stalks, plants do not always lodge. Utilizing lower plant populations that encourage thicker stalks may help to reduce damage from lodging. If fields are suspected to be infested, prompt harvesting will limit losses from lodging.

LYGUS BUG (TARNISHED PLANT BUG)

Lygus bug is primarily an insect pest concern in confection sunflowers. The damage has been named “kernel brown spot” because of the dark spot on the kernel. All evidence suggests the problem is due to feeding by lygus on the developing seed. Lygus are noted for being a pest of seed production to many crops. Their feeding preference is meristematic tissue, embryonic tissue or new growth of any kind. Lygus insert their mouthparts into the host, start a "pre-digestion pump" to inject saliva and start digestion, and then suck the fluid into the stomach. This is where the seed injury originates. The saliva is toxic to plant tissue, helping reduce the plant fluid into a digestible source. The result in sunflower seeds is the brown to black spot resulting from tissue death at that feeding site.

To minimize the damage which results in a quality reduction, a general approach to protecting sunflower from lygus and other seed feeding insects is being recommended. Sunflower is susceptible to lygus damage during flowering, from anthesis through seed hardening. A number of insecticides labeled for controlling head feeding insects in sunflower are available. Of these, the organophosphate (Lorsban) and pyrethroid (Asana XL, Baythroid XL, Warrior II) insecticides are labeled for control of lygus on numerous other crops. Lygus can be treated at the same time confection sunflower is treated for other insects, such as the seed weevil and banded sunflower moth.

Treatment Guidelines

***Confection*:** Entomologists found that populations of adult Lygus bugs at levels of 1 per 9 heads could result in economic loss to the producer through the reduction of seed quality. As a result, two treatments are needed to sufficiently protect confection sunflower heads from insect feeding: one application at the onset of pollen shed, or approximately 10% bloom, followed by a second treatment 7 days later. This program should adequately control insects on confection sunflower throughout flowering, minimizing the potential feeding damage.

***Oilseed*:** Oilseed sunflowers are not believed to be at risk to damage from Lygus feeding at this time.

SUNFLOWER BEETLE

Sunflower beetles begin feeding shortly after they emerge from overwintering. Emergence starts in mid-May. Most feeding by the adults is concentrated on the true leaves. Adults quickly begin laying pale yellow eggs singly on stems and the underside of leaves. Eggs hatch in about 8 days. The pale green, humpbacked larvae begin feeding, eating holes throughout the leaf. Larvae do not feed during the day, resting in the plant tops where they are easily observed.

Thresholds

***Adults*:** Treatment is recommended when scouting determines that an average of 1 to 2 beetles per plant can be found throughout the field.

***Larvae*:** When an average of 10 to 15 larvae per plant is found, defoliation levels of 25% to 30% would be expected. Treatment is suggested when damage levels reach this point and most larvae are 1/4 inch in size.

SUNFLOWER MIDGE

The midge is a small tan fly, 3/32 inch in length. The midge emerges in early July. They prefer to lay eggs on developing buds 1 to 2 inches in diameter. The cream to yellowish-orange larvae feed on bract tissue at first and later on the flowers and seeds. When populations are low and feeding is confined to the bracts, damage results in little economic loss. At higher populations, seed production is reduced or prevented. This type of injury appears as twisted and gnarled flowers. Often, infestations will be limited to field margins. When populations are large, damage may extend into the field and significant field losses may be observed. Historically, infestations and losses have increased with increased sunflower production. Also, environmental conditions contribute to midge outbreaks. Good soil moisture in the month of June promotes survival and emergence of midge.

Threshold: There are no effective chemical controls currently recognized for this pest. The best management strategy has been **rotation** to crops other than sunflower in the vicinity of large infestations. Staggering **planting dates** to promote different budding periods between fields can reduce the risk of damage to all fields in the same geographic areas. Late planting dates (June) also mitigate sunflower midge damage.

SUNFLOWER MOTH

The sunflower moth migrates to North Dakota from Southern states. Because of the migratory nature of the insect, it has not been a major problem in North Dakota. This grayish-tan moth moves into fields in early bloom. It deposits its eggs on the face of the flower. Damage is similar to that caused by the banded sunflower moth. Since female moths lay eggs on the face of sunflower heads, insecticide should be applied in early flowering (R5.1 - R5.3). Pheromone traps are available commercially for monitoring sunflower moths from R5.1 (early flowering) through R5.8 (80% pollen shed). Hot temperatures and high winds may impact the performance of pheromone traps in the field.

Threshold: For field scouting, 1 to 2 moths per 5 plants is necessary for treatment. For pheromone traps, an average of 4 moths per trap per day is needed for an insecticide application. If traps catches are less than 1 moth per trap per day, the infestation is considered non-economic.

SUNFLOWER SEED WEEVIL

The red sunflower seed weevil begins to emerge in early July and continues until mid-August. Peak emergence occurs in late July. Start counting adult seed weevils when the yellow ray petals are just beginning to show. Counts should continue until the economic threshold level has been reached or most plants have reached 70% pollen shed. A plant that has reached 70% pollen shed has few seeds still suitable for red seed weevil egg laying. Fields where most plants are at the 70% pollen shed stage should no longer be susceptible to further significant damage. When sampling, use the X pattern and begin counting at least 70 to 100 feet into the field to avoid field margin effects. Count the number of weevils on five plants at each site for a total of 25 plants. The ideal plant stage for treatment is when most individual plants are at 40% pollen shed. However, we recommend that treatment be considered when three out of 10 plants are just beginning to shed pollen.

Thresholds

***Oilseed Sunflower*:** The threshold can be calculated using the following formula:

$$\textbf{Threshold (weevils per head)} = \frac{\textbf{Cost of Insecticide Treatment}}{\textbf{(Market Price x 21.5) x (0.000022 x Plant Population + 0.18)}}$$

Example for calculating threshold: Price for Oilseed Sunflowers = $0.19						
Plant Population	**Treatment Cost ($)**					
	6.00	**7.00**	**8.00**	**9.00**	**10.00**	**11.00**
17,000	3	3	4	4	4	5
18,000	3	3	3	4	4	5
19,000	2	3	3	4	4	5
20,000	2	3	3	4	4	4
21,000	2	3	3	3	4	4
22,000	2	3	3	3	4	4
23,000	2	2	3	3	4	4
24,000	2	2	3	3	3	4
25,000	2	2	3	3	3	4

Estimation of absolute red sunflower seed weevil adults when sampling using a commercial formulation of mosquito repellent.					
Number counted in the field	Absolute number	Number counted in the field	Absolute number	Number counted in the field	Absolute number
1	1.4	7	12.4	13	23.1
2	2.9	8	14.2	14	24.9
3	4.4	9	16.0	15	26.6
4	5.8	10	17.8	16	29.3
5	7.3	11	19.5	17	31.1
6	10.7	12	21.3	18	32.9

Confection or Hulling Sunflower Market. Red sunflower seed weevil control on confection sunflower is based on a need to keep seed damage below 0.5% due to industry standards. Treatment is recommended when 1 to 2 weevils are found per plant. The **banded moth**, **seed weevil** and the **Lygus bug** have all impacted quality of these sunflowers the past three to four seasons. It is recommended at this time that **sunflowers grown for these markets be treated a minimum of two times**, once at early flowering and again 5 to 7 days later. With this type of program, a window of protection should be provided to minimize impact from all three of these seed damaging insect pests. Growers should plan treatment schedules early. When flowers begin blooming across the region, competition for access to aerial applicators increases.

SUNFLOWER STEM WEEVIL

The sunflower stem weevil can cause serious stalk breakage. This occurs when 25 to 30 larvae are present in a stalk, weakening the stalk when larvae make their overwintering cells in the stalk's base. Breakage is most likely to occur during drought stress or high winds.

The sunflower stem weevil is 3/16 inch in length, and grayish-brown with varying shaped white spots on the wing covers. The weevils emerge in mid to late June. Eggs are deposited in epidermal tissue of the stem. If controls are directed at the adults in order to minimize egg laying, treatments should be initiated during the first few days in July. About 50% of the eggs will be deposited by this weevil by mid-July. Scouting for these insects is difficult due to their size, coloration and habit of "playing dead." Examine 5 plants each at 5 locations and keep a record of the number of weevils found. Approach plants carefully to avoid alarming the weevils, causing them to drop to the ground. Scout from late June to mid-July.

Threshold: Treat for sunflower stem weevils when scouting determines that an average of 1 adult per three plants is found.

WIREWORMS

To decide whether wireworms are a potential problem, refer to the discussion in the corn insects section. Cruiser and Gaucho 600 are labeled as commercial seed treatment and use decisions must be made at time of seed purchase. Please see the seed treatment section in the introduction for more information.

INSECTICIDES REGISTERED FOR USE IN SUNFLOWER

INSECTICIDE	PRODUCT PER ACRE	PHI	Banded Sunflower Moth	Cutworms	Grasshoppers	Longhorned Beetle	Lygus Bugs	Sunflower Beetle	Sunflower Moth	Sunflower Seed Weevil	Sunflower Stem Weevil	Wireworms
Bacillus thuringiensis Biobit HP Dipel DF Xentari DF	0.5 - 1 lb 0.5 - 1 lb 0.5 - 2 lbs	None							●			
Bacillus thuringiensis Dipel ES	1.5 - 2.5 pts	None	●						●			
beta-cyfluthrin Baythroid XL *RUP*	0.8 - 2.8 fl oz	30 days	●	●	●			●	●	●	●	
carbaryl Sevin 4F Sevin XLR Plus	1 - 1.5 qts 1 - 1.5 qts	60 days for seed 30 days for grazing or forage		●				●	●		●	
chlorantraniliprole Coragen Prevathon	3.5 - 5 fl oz 14 - 20 fl oz	21 days	●						●			
chlorantraniliprole + lambda-cyhalothrin Besiege *RUP*	5 - 10 fl oz	45 days	●	●	●			●	●	●	●	
chlorpyrifos Lorsban 15G	8 oz per 1,000 row-feet	7 days		●								
chlorpyrifos Chlorpyrifos 4E AG Govern 4E Hatchet Lorsban 4E Lorsban Advanced Nufos 4E Vulcan Warhawk Whirlwind Yuma 4E *RUP*	PPI[1]: 2 - 4 pts Foliar: 1 -2 pts	42 days Do not allow grazing in treated areas	●	●	●		●	●	●	●	●	
chlorpyrifos + lambda cyhalothrin Cobalt Advanced *RUP*	6 - 38 fl oz	45 days Do not allow grazing in treated areas	●	●	●		●	●	●	●	●	
chlorpyrifos + zeta-cypermethrin Stallion *RUP*	3.75 - 11.75 fl oz	42 days Do not allow grazing in treated areas	●	●	●	●		●	●	●	●	
cyantraniliprole Exirel	7 - 20.5	7 days	●	●					●			
cyantraniliprole Fortenza[3]	0.1 - 0.2 mg ai per seed or 0.56 – 1.1 fl oz per 100,000 seeds	None. Consult label for rotational crop restrictions.		●								●
cyfluthrin Tombstone Tombstone Helios *RUP*	0.8 - 2.8 fl oz	30 days	●	●	●			●	●	●	●	
deltamethrin Delta Gold *RUP*	1 - 1.5 fl oz	21 days	●	●	●			●	●	●	●	
esfenvalerate Asana XL *RUP*	5.8 - 9.6 fl oz[2]	28 days	●	●	●			●	●	●	●	

INSECTICIDE	PRODUCT PER ACRE	PHI	Banded Sunflower Moth	Cutworms	Grasshoppers	Longhorned Beetle	Lygus Bugs	Sunflower Beetle	Sunflower Moth	Sunflower Seed Weevil	Sunflower Stem Weevil	Wireworms
gamma-cyhalothrin												
Declare *RUP*	0.77 - 1.54 fl oz	45 days	●	●	●			●	●	●	●	
imidacloprid												
Dyna-Shield Imidacloprid 5	12.8 fl oz per cwt	45 days										●
Gaucho 600												
Senator 600FS												
lambda-cyhalothrin												
Grizzly Too	0.96 - 1.92 fl oz	45 days										
Kendo	1.92 - 3.84 fl oz											
Lambda-Cy	1.92 - 3.84 fl oz											
LambdaStar	1.92 - 3.84 fl oz											
Lambda-T	1.92 - 3.84 fl oz											
Lamcap	1.92 - 3.84 fl oz											
Nufarm Lambda-Cyhalothrin 1EC	1.92 - 3.84 fl oz		●	●	●			●	●	●	●	
Paradigm VC	1.92 - 3.84 fl oz											
Province	1.92 - 3.84 fl oz											
Silencer	1.92 - 3.84 fl oz											
Silencer VXN	1.92 - 3.84 fl oz											
Warrior II *RUP*	0.96 - 1.92 fl oz											
thiamethoxam												
Cruiser 5FS	0.25 mg active ingredient per seed	None						●				●
zeta-cypermethrin												
Mustang Maxx *RUP*	At Planting: 4 fl oz	30 days		●								●
zeta-cypermethrin	Foliar Application:	30 days										
Mustang Maxx *RUP*	1.28 - 4 fl oz		●	●	●	●		●	●	●	●	

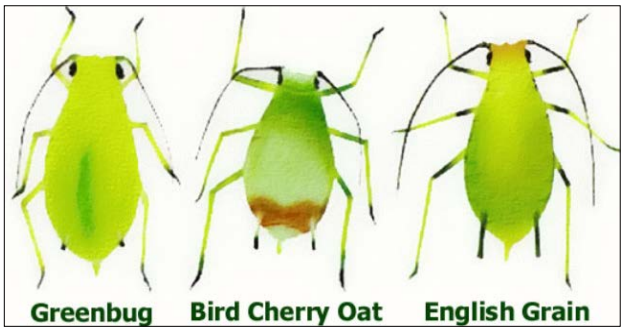
RUP = Restricted Use Pesticide
● = Control
[1] = PPI applications of chlorpyrifos products for control of cutworms only
[2] = For sunflower beetles only, a lower rate is available - 1.45-5.8 fl oz per acre of esfenvalerate
[3] = May provide protection against wireworm when combined with Cruiser 5FS

WHEAT INSECTS

Other Resources Available Through NDSU Extension Service:

Publications	E1479	Integrated Pest Management of Wheat Stem Sawfly in North Dakota (2016)
	E1330	Integrated Pest Management of the Wheat Midge in North Dakota (2016)
	E1230	Cereal Leaf Beetle Management (2016)
	E830	The Armyworm and the Army Cutworm (revised 2018)

APHIDS



Greenbug - pale green with darker stripe down back.
Bird Cherry Oat Aphid - olive green, brownish patch at the base of cornicles.
English Grain Aphid - bright green with long black cornicles. The greenbug, English grain aphid and bird cherry oat aphids are the principal species that cause problems in North Dakota small grains. None of these aphids are known to overwinter in North Dakota; they migrate to the region from the South in late spring. The greenbug is the most injurious because it injects a toxin with its saliva during feeding. The English grain aphid is the most common aphid seen in small grains. Its populations grow rapidly when feeding on wheat heads. The bird cherry oat aphid feeds primarily on leaves in the lower part of the small grain plant. These aphids transmit barley yellow dwarf virus. When aphid populations are high, the disease can spread through small grain fields. At greatest risk are later planted fields which attract migrating aphids that are moving from more mature fields.

Thresholds: English Grain, Bird Cherry Oat, Greenbug

To protect small grains from yield loss due to aphid feeding, the treatment threshold is 85% stems with more than one aphid present or 12-15 aphids per stem, prior to complete heading. Field scouting should begin at stem elongation and continue up to the heading stage of wheat. Aphid populations at or above the thresholds during these growth stages will result in economic injury to plants.

The greatest risk of yield loss from aphids feeding on grains is in the vegetative to boot stages. Significant yield reductions after the onset of flowering could not be demonstrated in research published from South Dakota in 1997 (Voss et al., 1997. Journal of Economic Entomology 90: 1346-1350). Reasons for these conclusions were that: after heading the only major yield component aphids can affect is seed weight; aphids are unable to sustain the very large populations necessary to achieve significant impact on this factor. Other components of yield are determined earlier (number of spikelets - determined at jointing; number of seeds - determined at flowering).

***Russian Wheat Aphid (RWA)*:**

15% to 20% of tillers infested up to flowering; 20+% infested tillers from flowering to early milk stage

Note: A tiller is infested whether it has one or several RWA present. RWA have only been found in southwest North Dakota during late summer; no economic damage has been reported. No RWA have been reported in North Dakota since the early '90s. Occasionally, RWA have overwintered during mild winters in Montana.

Natural Controls

Lady beetles, aphid lions, syrphid fly larvae, and parasitoid wasps play a major role in reducing aphid populations. When natural enemies are present in large numbers, and the crop is well developed, farmers are discouraged from spraying fields.

ARMYWORMS

Armyworm outbreaks in North Dakota can occur when large migrations of moths from Southern states occur in late spring and early summer. Moths prefer to lay eggs in moist, shady areas where small grains or grasses have lodged or been damaged by hail or wind. Armyworms feed at night and hide under vegetation or in loose soil during the day. To scout for armyworms in grains, part the plants and inspect the soil for fecal pellets. If pellets or feeding damage is found, look for larvae under plant trash, soil clods or in soil cracks.

Threshold: Treat when 4 to 5 or more worms per square foot are present.

Migrating Armyworms: Treat a couple of swaths ahead of the infestation in the direction of movement to form a barrier strip.

CEREAL LEAF BEETLE

The cereal leaf beetle is an imported insect pest from Europe. This insect has been confirmed from **Burke, Cavalier, McKenzie, Nelson, Renville, Ward and Williams counties of North Dakota**. It was first detected in Michigan in 1962, Utah in 1984, and Montana in 1989. The cereal leaf beetle is a serious pest of barley and wheat in Montana. Both adults and larvae of the cereal leaf beetle damage grain crops through their foliar feeding. The larvae are the most damaging stage and the target of control measures. Generally, the newer plant tissue is preferred with feeding occurring on the upper leaf surface causing characteristic elongated slits.

Monitoring and Treatment Threshold: The first sign of CLB activity in the spring is adult feeding damage on the plant foliage. While this is the first sign of adult activity, adults are not the target of control. Eggs and larvae are monitored by plant inspection since thresholds are expressed as egg and larvae numbers per plant or per stem. Examine 10 plants per location and select 1 location for every 10 acres of field. Count number of eggs and larvae per plant (small plants) or per stem (larger plants) and get an average number of eggs and larvae, based on the samples you have taken. Boot stage is a critical point in plant development and impact of cereal leaf beetle feeding damage can be felt on both yield and grain quality.

Before boot stage, the threshold is 3 eggs and/or larvae or more per plant (including all the tillers present before the emergence of the flag leaf). Larvae feeding in early growth stages can have a general impact on plant vigor. When the flag leaf emerges, feeding is generally restricted to the flag leaf which can significantly impact grain yield and quality.
At the boot stage - 1 larva or more per flag leaf.

CUTWORMS

Several cutworm species affect regional crops. In western North Dakota, the pale western cutworm and the army cutworm are important pests of small grains. Eggs of pale western hatch in the spring and larvae feed underground. Eggs of the army cutworm hatch in the fall and spring feeding is above ground. In eastern North Dakota, the dingy cutworm, *Feltia jaculifera*, overwinters as a partially grown larva and is one of the first cutworm species to cause problems during crop emergence from early to mid-May. The moth of the dingy cutworm is known to lay her eggs on sunflower heads from mid-July through September. Crops following sunflowers in rotation are at greatest risk of injury by this cutworm. Other cutworms, the red-backed, *Exoa ochregaster*, and the darksided, *Exoa messoria*, overwinter as eggs which hatch in mid to late May. Eggs are laid in the fall and survive in weedy, wet, and reduced-tillage areas. Feeding injury by these cutworms normally occurs in late May to early June.

Threshold: Treatment is recommended when cutworms number 4 to 5 per square foot.

GRASSHOPPERS

In the Northern Plains, grasshopper egg hatch normally begins in late April to early May. Peak hatch occurs about mid-June. Heavy infestations typically occur in areas of low rainfall or during drought years. Outbreaks are usually preceded by several years of hot, dry summers and warm falls. Cool, wet weather increases disease occurrence and delays development of grasshoppers, reducing the overall population.

Cultural Control Methods

***Early seeding*:** Allows for early establishment and vigorous growth of plants.

***Crop rotation*:** Avoid planting in areas of high egg deposits. Fields with late-maturing crops or green plant cover attract adults which then lay eggs.

***Tillage*:** Summer fallow will act as a trap crop, attracting females for egg laying. Spring tillage of these sites will reduce successful emergence of nymphs.

Threshold: The threatening rating is considered the action threshold for grasshoppers. For example, grasshopper control is advised whenever 50 or more small nymphs per square yard can be found in adjacent, non-crop areas, or when 30 or more nymphs per square yard can be found within the field. When 20 or more adults per square yard are found in field margins or 8 to 14 adults per square yard are occurring in the crop, treatment would be justified. Since it is difficult to estimate the number of grasshoppers per square yard when population densities are high, pest managers can use four 180-degree sweeps with a 15-inch sweep net, which is equivalent to the number of adult (or nymph) grasshoppers per square yard.

	Nymphs per square yard		**Adults per square yard**	
Rating	Margin	Field	Margin	Field
Light	25-35	15-25	10-20	3-7
Threatening	50-75	30-45	21-40	8-14
Severe	100-150	60-90	41-80	15-28
Very Severe	200+	120+	80+	28+

Many of the grasshopper infestations will be the heaviest on the field margins. Treating these areas may lessen the total numbers of grasshoppers successfully entering a field.

HESSIAN FLY

The Hessian fly overwinters as a maggot or pupa in winter wheat, volunteer grain, and wheat stubble. Overwintering maggots pupate and emerge as adults from April to May, infesting fall and spring planted wheat. By June, maggots pupate (flaxseed stage), emerging as adults in August to lay eggs for the overwintering generation.

Managing Hessian Fly

***Winter wheat planting date*:** Winter wheat will act as a bridge to get Hessian fly from one season to the next. Delaying planting in the fall should reduce the risk of infestations. Suggested planting dates for ND are: north - September 1 - 15; south - September 15 to 30.

***Tillage*:** Burying stubble and destroying volunteer grain after the first killing frost or early in the spring before fly emergence helps suppress adult populations.

***Rotation*:** Rotate wheat with nonsusceptible crops (oats, corn, soybean, sunflower, and flax).

***Resistant varieties*:** Two South Dakota releases, Guard and Shield, are hard red spring wheats. They are semi-dwarf varieties. Guard is reported to be prone to shattering.

***Chemical control*:** Imidacloprid and thiamethoxam are registered as active ingredients for use at planting time treatment or as a seed treatment on wheat. Warrior II is also labeled as a foliar application when adults emerge. However, population levels of this pest would rarely warrant the need for such treatments in North Dakota.

WHEAT MIDGE

Though infestation pressure from this insect has declined, it remains an economic concern for wheat prodcuers in North Dakota. Since 1996, wheat midge has been detected in the northern half of North Dakota. Delayed planting of wheat due to excessively wet soils in the spring could favor wheat midge population increase. Any factor which results in having heading wheat present in the fields during midge emergence will put a wheat crop at risk to infestation.

The adult midge is active from late June to early August. Peak activity is from late June to mid-July. A model using daily temperatures to calculate degree day accumulations allows for a more accurate prediction of local adult emergence. Wheat is attractive for egg laying by midge from the time the head emerges from the boot through flowering. Insecticides for the control of midge are effective on the adult; however, control of the orange larvae, which feed on the developing kernels, has not been demonstrated due to protection within the glume.

Degree Days as a Tool for Wheat Midge Management

Based on data from Canada, the threshold temperature for wheat midge development is 40̊ F. Observations indicate the following DD accumulations for events in the midge population.

DD	Biological Event
450	The midge breaks the larval cocoon and moves close to soil surface to form the pupal cocoon
1300	10% of the females will have emerged
1475	About 50% of the females will have emerged
1600	About 90% of the females will have emerged

Identifying Wheat Fields at Risk for Midge Infestation

Based on North Dakota field observations, midge larval infestations were the greatest when heading occurred during peak female emergence (1475 DD). When using 40 F as a threshold for wheat development (*normally wheat development is monitored with 32 degrees*), heading occurs around 1000 - 1100 DD. Using this information, the following midge activity is expected based on degree day accumulations at time of wheat planting. There is a wheat growth and midge emergence model available through the North Dakota Agricultural Weather Network (NDAWN) Internet site and can be found at: https://ndawn.ndsu.nodak.edu

Wheat Midge Degree Days Used as a Guideline for HRSW Risk Assessment
HRSW planted **PRIOR** to accumulating **200 DD** will head before wheat midge emerge.
HRSW planted FROM **200 to 600 DD** will be heading at the time wheat midge are emerging.
HRSW planted **AFTER 600 DD** will head after peak emergence and should be at low risk to midge infestation (higher risk of frost, however).

Thresholds for Wheat: Examine wheat heads at dusk (9 p.m. and later when temperatures are above 60̊ F and wind speed less than 6 mph). The orange-colored adult midge can be seen laying eggs on the wheat heads. Plants are susceptible as the head emerges from the boot. In general, **Hard Red Spring Wheat** treatment is warranted when 1 or more midge are observed for every 4 or 5 heads. **Durum Wheat** treatment is warranted when 1 or more midge are observed for every 7 or 8 wheat heads. Treatments after 50% of the first heads have flowered are not recommended due to reduced levels of efficacy and for the protection of a parasitic wasp that attacks the midge eggs.

Detecting adult midge

Pheromone traps and sticky traps may be used to capture adult midges active in wheat fields. A simple trap design would be a white Styrofoam plate, attached to the top and bottom of a surveyor's flag. The trapping surface can be coated with Tanglefoot® or vegetable oil. The trap can alert an individual to the presence of midge and their identity, but it does not provide information about the need to treat.

***Resistant wheat variety*:** 'Egan' hard red spring wheat was developed by the Montana Agricultural Experiment Station and released in 2014. Egan is resistant to wheat midge due to antibiosis conferred by resistance gene *Sm1*, and also contains a gene for high protein and for stripe rust resistance (*Yr36*).

WHEAT STEM MAGGOT

The maggot tunnels in stems of wheat, resulting in a white head that can be easily pulled out of the boot. This damage becomes evident after flowering. Infestations rarely exceed 5% and fail to become an economic concern. Crop rotation and destruction of volunteer grain are the most effective methods of reducing maggot populations. Preliminary research data from NDSU suggests that tank mixing insecticides with the early season herbicides during 5-leaf to jointing wheat helped reduce the incidence of white heads and increased yields when large numbers of wheat stem maggot adults are present. Time insecticide application during peak adult activity and before larvae bore into stem. No economic threshold has been developed.

WHEAT STEM SAWFLY

Sawfly damage occurs annually in North Dakota. This insect primarily affects wheat in the central and western areas of the state. The larvae tunnel in the stem, reducing grain yield by 10% to 25% or higher yield losses when infestations are severe. Additional loss

occurs when infested stems lodge, rendering the grain unharvestable. Larvae overwinter in the wheat stubble making infested sites the source of next year's problems.

Managing Wheat Stem Sawfly

***Chemical control*:** Insecticides have been found to be ineffective in controlling wheat stem sawfly.

***Harvesting*:** Swath fields with the heaviest sawfly infestations at 30% to 35% moisture before significant lodging occurs. This requires field surveys to determine infestation levels. Infested stems have a reddish-brown spot below the second or third node. Examine 50 consecutive stems in a drill row from at least two sites (one near the field margin, another near the center). Determine the percent of stems infested at each site. **If more than 15% of stems are infested by sawflies, producers should swath the wheat crop.** Producers should swath sawfly-infested wheat as soon as kernel moisture drops below 40% to save infested stems before they lodge. If producers decide to swath grain, use a high swathing height to conserve the parasitoids that attack wheat stem sawfly. Research from Montana State University has shown that taller residue (at least the lower ⅓ of the plant) is better for conserving the parasitoids. If 10 to 15% of the crop was cut by sawfly during the current field season, a solid-stemmed variety of wheat is recommended for the upcoming field season.

***Fall tillage*:** Shallow fall tillage to dislodge stubble and leave it on the soil surface can result in 90% mortality of overwintering larvae. Tillage can be limited to areas where surveys indicated infestations within the field or strip.

***Crop rotation*:** Non-host crops are oats, flax, sunflower, legumes, and to a lesser extent barley, rye, durum or winter wheat.

***Resistant wheat varieties*:** Resistant wheats have a solid-stem trait which is unsuitable for sawfly development. Please note the 2009 release of the NDAES solid-stem hard red spring wheat release named 'Mott', which has good resistance to wheat stem sawfly and high yield.

Wheat Stem Sawfly Resistant Wheat Variety Descriptions

Variety	Type[1]	Height	Origin[2]	Year Released	Straw Strength	Maturity	Test Weight	Protein	Yield[3]
AC Lillian	HRS	standard	AC	2005	med	med	high	high	high
Choteau	HRS	semidwarf	MAES	2003	strong	med	avg	avg	high
Corbin	HRS	semidwarf	WB	2006	strong	early	high	high	high
Duclair	HRS	semidwarf	MAES	2011	strong	med	avg	avg	high
Mott	HRS	standard	NDAES	2009	strong	med-late	high	high	high
SY Tyra	HRS	semidwarf	AP	2011	strong	med	high	avg	high
WB 9377	HRS	semidwarf	WB	2014	strong	early	high	high	high
WB 9879 CLP	HRS	semidwarf	WB	2012	strong	med	high	high	high
WB Gunnison*	HRS	semidwarf	WB	2011	med	med	high	avg	high
Bearpaw	HRW	semidwarf	MAES	2011	strong	med	avg	avg	avg
Judee	HRW	semidwarf	MAES	2011	strong	med	avg	avg	avg
Loma	HRW	semidwarf	MAES	2016	med	med-late	avg	avg	high
Warhorse	HRW	semidwarf	MAES	2013	strong	med	high	high	high
WB Quake	HRW	semidwarf	WB	2011	strong	med-late	high	avg	avg
Agawam	HWS	semidwarf	WB	2005	strong	med	high	avg	high

*indicates a non-attractive variety.

[1]HRS = Hard Red Spring Wheat, HRW = Hard Red Winter Wheat, HWS = Hard White Spring Wheat.

[2]AC = Agriculture Canada, AP = Syngenta AgriPro; MAES = Montana Agricultural Experiment Station, NDAES = North Dakota Agricultural Experiment Station, WB = WestBred

[3]Yields are relative to sawfly resistant varieties.

WIREWORMS

Wireworms are most likely to be problems when crops follow pasture or grassland. Infestations often are found in coarse textured soils (sandy loam) where moisture is abundant, perhaps in low spots of fields.

Thresholds: There is no easy way to estimate wireworm infestations. Two methods are currently used.

***Soil Sampling*:** Sample 20, well spaced, 1 square foot sites to a depth of 4 to 6 inches for every 40 acres being planted. If an average of 1 wireworm per square foot is found, treatment would be justified.

***Solar Baiting*:** In September, establish bait stations for 2 to 3 weeks before freeze. Place bait stations randomly through the field, but representing all areas of the field. There should be 10 - 12 stations per 40 acre field. Place one cup wheat and one cup shelled corn in a 4- to 6-inch deep hole. Cover grain with soil and then an 18-inch square piece of clear plastic. Dig up the grain. If an average of one or more wireworm larvae is found per station, treatment would be justified.

Seed Treatment: Seed treatments and/or planter box treatment are available for use on wheat for managing wireworm. Please the seed treatment section in the introduction for more information.

Caution: Do not use treated seed for feed or food purposes. Prevent the contamination of commercial grain by thoroughly cleaning bins, grain augers and trucks that have been used to store, handle and/or home treat seed.

INSECTICIDES REGISTERED FOR USE IN WHEAT

INSECTICIDE	PRODUCT PER ACRE	PHI	Aphids	Armyworms	Cereal Leaf Beetle	Cutworms	Grasshoppers	Hessian Fly	Wheat Midge	Wheat Stem Maggot	Wireworms
alpha-cypermethrin Fastac CS Fastac EC *RUP*	1.3 - 3.8 fl oz	14 days	●	●	●	●	●				
Bacillus thuringiensis Biobit HP Dipel DF Dipel ES Xentari DF	0.5 - 2 lbs 1 - 2 lbs 2 - 4 pts 0.5 - 2 lbs	None		‡							
beta-cyfluthrin Baythroid XL *RUP*	1 - 2.4 fl oz	30 days 3 days for grazing or forage	●	‡	●	●	●			●	
chlorantraniliprole Prevathon	14 - 20 fl oz	14 days		●							
chlorantraniliprole + lambda-cyhalothrin Besiege *RUP*	5 - 10 fl oz	30 days	●	●	●	●	●	●	●		
chlorpyrifos Chlorpyrifos 4E AG Govern 4E Hatchet Lorsban 4E Lorsban Advanced Nufos 4E Vulcan Warhawk Whirlwind Yuma 4E *RUP*	0.5 - 1 pt	28 days for grain and straw 14 days for grazing, forage and hay	●	●	●	†	●		●		
chlorpyrifos + lambda-cyhalothrin Cobalt Advanced *RUP*	6 - 25 fl oz	28 days for grain and straw 14 days for grazing, forage and hay	●	●	●	●	●		●		
chlorpyrifos + zeta-cypermethrin Stallion *RUP*	3.75 - 11.75 fl oz	28 days for grain and straw 14 days for grazing, forage and hay	●	●	●	●	●			●	
clothianidin Intego SUITE Cereals OF[1] NipsIt SUITE Cereals OF[1] NipsIt Inside Insecticide[1]	5.2 fl oz per cwt 5 - 7.5 fl oz per cwt 0.25 - 1.79 fl oz per cwt	**REI:** 24 hrs	*				*	●			●
cyfluthrin Tombstone Tombstone Helios *RUP*	1 - 2.4 fl oz	30 days 3 days for grazing or forage	●	‡	●	●	●				
diflubenzuron Dimilin 2L **FOR USE WEST OF US HIGHWAY 81 ONLY** *RUP*	1 - 4 fl oz	50 days for grain and straw 15 days for hay 3 days for forage			‡		‡				
dimethoate Dimate 4E Dimethoate 4E Dimethoate 4EC Dimethoate 400	0.5 - 0.75 pt	35 days for grain 14 days for grazing	●				●				

INSECTICIDE	PRODUCT PER ACRE	PHI	Aphids	Armyworms	Cereal Leaf Beetle	Cutworms	Grasshoppers	Hessian Fly	Wheat Midge	Wheat Stem Maggot	Wireworms
flupyradifurone Sivanto Prime	7 - 10.5 fl oz	7 days for forage 21 days grain, stover and straw	●								
gamma-cyhalothrin Declare *RUP*	0.77 - 1.54 fl oz	30 days	●	●	●	●	●	●	●		
imidacloprid Attendant 480FS Attendant 600 Dyna-Shield Imidacloprid 5 Gaucho 600 Senator 600FS	0.16 - 0.32 fl oz per cwt 0.13 - 0.26 fl oz per cwt 0.13 - 0.26 fl oz per cwt 0.13 - 0.26 fl oz per cwt 0.13 - 0.26 fl oz per cwt	45 days for grazing or feeding									†
imidacloprid Attendant 480FS Attendant 600 Dyna-Shield Imidacloprid 5 Gaucho 600 Senator 600FS	1 - 3 fl oz per cwt 0.8 - 2.4 fl oz per cwt 0.8 - 2.4 fl oz per cwt 0.8 - 2.4 fl oz per cwt 0.8 - 2.4 fl oz per cwt	45 days for grazing or feeding	*					●			●
imidacloprid* Enhance AW	4 oz per cwt	45 days for grazing or feeding	*					†			†
imidacloprid* Foothold Extra Foothold Virock Sativa IM Max	3.4 - 5 fl oz per cwt	45 days for grazing or feeding	*					●			●
imidacloprid Raxil PRO Shield Sativa IM RTU	5 fl oz per cwt	45 days for grazing or feeding	*								†
imidacloprid Rancona Crest Warden Cereals HR	5 - 8.33 fl oz per cwt	45 days for grazing or forage	*					†			†
imidacloprid Rancona Crest WR Warden Cereals WR	5 - 8.33 fl oz per cwt	45 days for grazing or forage	*								†
lambda-cyhalothrin Grizzly Too Kendo Lambda-Cy LambdaStar Lambda-T Lamcap Nufarm Lambda-Cyhalothrin 1EC Paradigm VC Province Silencer Silencer VXN Warrior II *RUP*	0.96 - 1.92 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 1.92 - 3.84 fl oz 0.96 - 1.92 fl oz	30 days for grain and straw 7 days for grazing and forage	●	●	●	●	●	●	●	●	
malathion Cheminova Malathion 57% Cheminov 57EC	1 - 1.5 pts 1.5 - 1.6 pts	7 days	●		●		●				
malathion Malathion 5	1 - 2 pts	7 days	●	●	●		●				
malathion Fyfanon ULV AG	4 - 8 fl oz	7 days			●		●	●	●		
spinetoram Radiant SC	2 - 6 fl oz	21 days for grain and straw 3 days for forage, fodder and hay		●	●		†		●		

INSECTICIDE	PRODUCT PER ACRE	PHI	Aphids	Armyworms	Cereal Leaf Beetle	Cutworms	Grasshoppers	Hessian Fly	Wheat Midge	Wheat Stem Maggot	Wireworms
spinosad Blackhawk Entrust Spintor 2SC Tracer	 1.1 - 3.3 oz 0.5 - 2 fl oz 2 - 6 fl oz 1 - 3 fl oz	21 days for grain and straw 3 days for forage, fodder and hay		‡	●		†				
sulfoxaflor Transform WG	0.75 - 1.5 oz	14 days for grain and straw harvest 7 days for grazing, forage, fodder and hay harvest	●								
thiamethoxam* Cruiser 5FS	0.75 - 1.33 fl oz per cwt	None	*					●			●
thiamethoxam Cruiser Maxx Cereals[2] Cruiser Maxx Vibrance Cereals	5 fl oz per cwt 5 - 10 fl oz per cwt	Do not graze or feed livestock on treated areas for 45 days	*								●
thiamethoxam Warden Cereals 360[3] Warden Cereals WR II[3]	5 fl oz per cwt	Warden Cereals WR II: Do not graze or feed livestock on treated areas for 45 days	*								●
zeta-cypermethrin Mustang Maxx *RUP*	1.28 - 4 fl oz	14 days	●	●	●	●	●				

RUP = Restricted Use Pesticide
● = Control
† = Suppression only
‡ = Control of first and second instar larvae or control of young grasshoppers, depending on product indicated
* = Seed treatments may not provide control of early season grain aphids
[1] = For protection against early season aphids, grasshoppers, Hessian fly, or heavy wireworms pressure, add 1.4 to 1.5 fl oz per cwt of NipsIt INSIDE Insecticide to NipsIt SUITE Cereals OF or Intego SUITE Cereals OF; consult each label for registered use rates and follow all label instructions.
[2] = For protection against early season aphids, Cruiser Maxx Cereals must be mixed with 0.48 - 1 fl oz per cwt of Cruiser 5FS; consult each label for registered use rates and follow all label instructions.
[3] = For aphid and wireworm control, add up to 0.8 fl oz per cwt of Cruiser 5FS.

STORED GRAIN

Preparing Bins For Storage: The key to good grain storage is anticipating and preventing potential problems through good bin management.

Before treating with protectant, make sure that the bins are free of insect-infested grain. Leftover grain should be removed from the bin, and the walls should be swept and vacuumed. All grain handling equipment including augers, combines, trucks and wagons should be thoroughly cleaned and grain residues removed before harvest.

A residual bin spray such as Malathion, Tempo, Diacon or a combination of the two should be applied to all interior bin surface areas 2 to 3 weeks before new grain is placed in the bin. The treatment will kill insects merging from their hiding places (cracks, crevices, under floors and in aeration systems). Also, insects crawling or flying in from the outside will be killed.

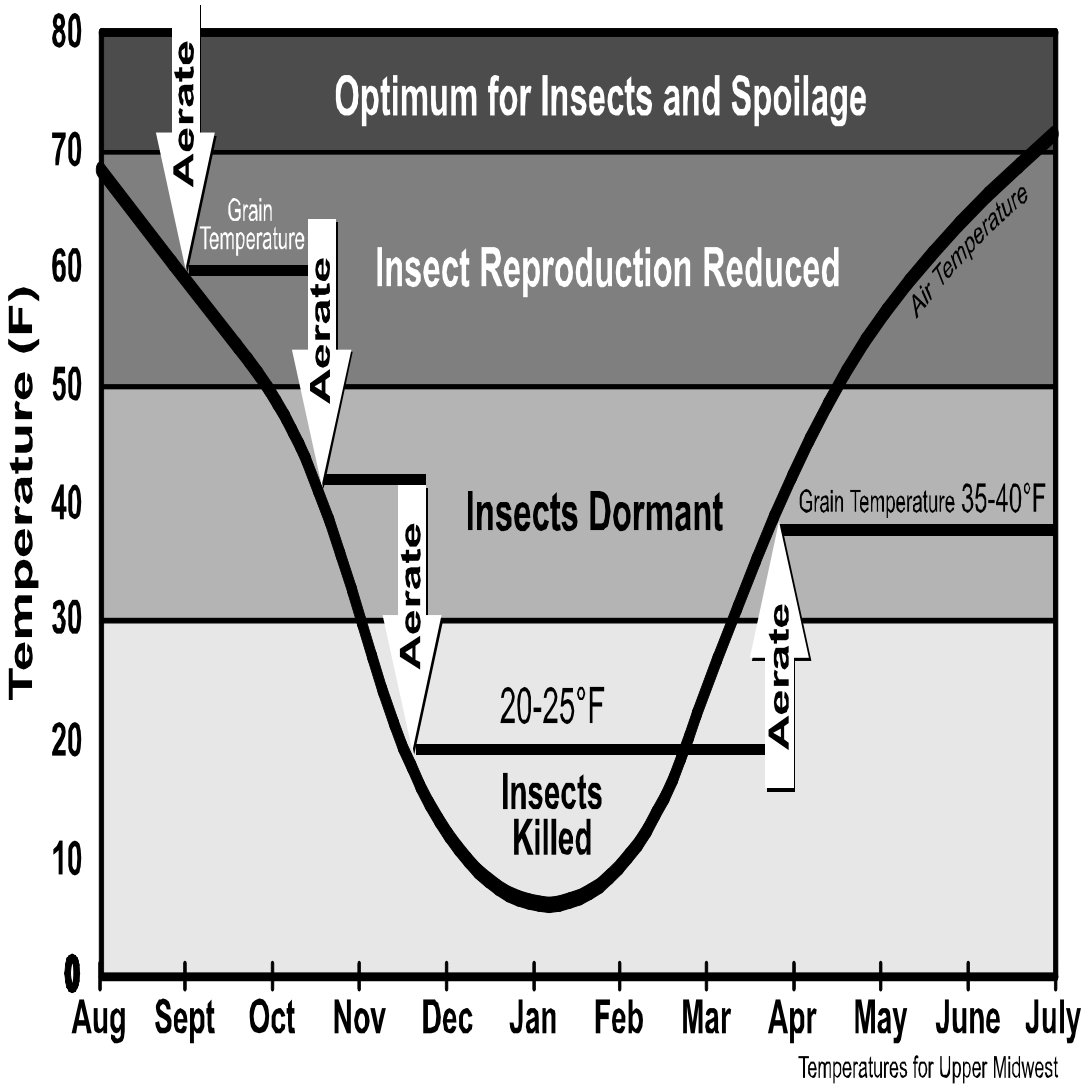
Apply the spray to as many surfaces as possible, especially joints, seams, cracks, ledges and corners. Spray the ceiling, walls and floors to the point of runoff. Use a coarse spray at a pressure of more than 30 lb per square inch and aim for the cracks and crevices.

Spray beneath the bin, its supports, and a 6 ft border around the outside foundation. Treat the outside surface, especially cracks and ledges near doors and fans.

The increased use of metal bins with perforated floors for grain drying and aeration has helped produce a serious insect problem in farm-stored grain. Grain dockage (broken kernels, grain dust, and chaff) sifts through the floor perforations and collects in the subfloor plenum creating a favorable environment for insect development. Unfortunately, the floors are usually difficult to remove, making inspection, cleaning and insecticide spraying in the plenum difficult if not impractical. The infested plenum may be disinfected with an approved fumigant such as chloropicrin.

TYPE OF TREATMENT	CROP	INSECTICIDE	Comments
Residual Bin Sprays: (empty bins) Clean, sweep and spray all bins before harvest. **Note**: Do not add grain to a treated bin for at least 24 hours or until walls have dried thoroughly.	All bins	**S-methoprene** Diacon IGR Diacon-D, IGR	Active ingredient is an insect growth regulator. It prevents the development of larvae into adults. Adult insects are NOT controlled. Recommend that it is mixed with Centynal for adulticide.
		malathion	May not provide control of Indian meal moth. Check label for listing of this use.
		cyfluthrin Tempo SC Ultra	Check product label for rates of application. Do not apply to grain.
		chlorpyrifos-methyl + cyfluthrin Storcide II	Storcide combines the active ingredients of Reldan (chlorpyrifos methyl) and Decis (deltamethrin).
		deltamethrin Centynal Suspend Polyzone	Control a wide range of pests; treat inside of clean bins prior to storing grains. Can be used in outdoor perimeter applications around bins and on surrounding vegetation.
		deltamethrin **S-methoprene** Diacon IGR Plus	Combination insect growth regulator and adulticide. Control a wide range of pests; treat inside of clean bins prior to storing grains. Can be used in outdoor perimeter applications around bins and on surrounding vegetation.
Surface Treatment: Apply insecticide to surface after grain is binned. **Note**: To ensure control, remove all surface crusting and webbing before treatment.	Barley Corn Oats Rye Soybean Sunflower Wheat	***Bacillus thuringienesis, subspecies kurstaki*** Dipel	(Indian meal moth larvae only.) As a surface treatment, apply ½ lb of Dipel in 5-10 gal. of water per 500 sq ft of grain surface area: mix into top 4 inches.
		(S)-methoprene Diacon II Diacon-D	Active ingredient is an insect growth regulator. It prevents the development of larvae into adults. Adult insects are not controlled. Soybeans are <u>not</u> on Diacon II and Diacon-D labels. Canola and legumes are also on Diacon-D label.
		diatomaceous earth Insecto, Dryacide	4.0 lbs per 1,000 sq ft. Treat only the top 1 to 2 ft of the grain mass.
Grain Protectant: All the grain is treated when bin is being filled. Insecticides may be applied as a spray or dust to the grain as it is being augered into the bin. These products may also be used for treatment of the grain surface for registered commodities.	Corn Sorghum	**pirimiphos-methyl** Actellic 5E	No food or feeding restrictions. Lesser grain borer is not listed as a target pest.
	Barley Corn Oats Rye Sorghum Wheat	**S-methoprene** Diacon IGR Diacon-D IGR	Active ingredient is an insect growth regulator. It prevents the development of larvae into adults. Adult insects are not controlled. Combine with Centynal insecticide when adult insects are present. Soybeans are <u>not</u> on Diacon IGR and Diacon-D labels. Canola, sunflower and legumes are on these Diacon labels.
		malathion	May not provide control of Indian meal moth. Products not labeled specifically for application to stored grain should not be used.
		deltamethrin Centynal EC Suspend	Broad spectrum insecticide for control of many stored product pests. Apply as grain enters storage, Can be used for treating seeds.
		chlorpyrifos-methyl + deltamethrin Storcide II	Storcide II combines the active ingredients of Reldan (chlorpyrifos methyl) and Decis (deltamethrin). Storicide II does NOT have export restrictions on the label.
		deltamethrin **S-methoprene** Diacon IGR Plus	Combination insect growth regulator and adulticide. Protects stored grains and seeds againsts damage from Indian meal moth, saw-toothed grain beetle, red flour beetle, confused flour beetle, rice weevil, maize weevil and other listed pests. Long residual control, reduces rebound of infestations.

Cool Grain to Prevent Storage Problems



* Prevent crusting due to moisture migration by cooling grain to within 15°F of average outdoor temperatures.

* Cooling grain by 10°F doubles its allowable storage time

Dr. Kenneth J. Hellevang, PE
NDSU Extension Service

FUMIGANTS

The two principal types of fumigants used for the treatment of farm-stored grain are liquids (chloropicrin) and solids (aluminum phosphide). Limited amounts of methyl bromide (a compressed gas) are also used in farm storage. These vapors permeate the grain mass and kill insects by suffocation or by chemical action on their breathing system, preventing the assimilation of oxygen or other vital functions. In order for a grain fumigant to kill insects, it is necessary that the vapor or gas remain at a toxic concentration for a sufficient period of time for the insects to contact the gas. No fumigant kills insects instantaneously; usually it requires several hours of exposure, even under ideal conditions, for fumigating.

Some Important Steps for Successful Fumigation

1. Do not attempt fumigating grain unless the grain temperature is 60º F or higher.
2. Before applying fumigants, level the grain surface and break up any surface "caking."
3. Apply fumigants on a calm day. Seal bin as tightly as possible. The fumigant should be retained in the grain and not allowed to "leak" out. Use polyethylene and/or caulk to cover or seal all holes and cracks. Cover the grain with a tarpaulin or polyethylene if there is a large air space above the grain.
4. All fumigants should be handled with extreme care because the fumes are highly toxic. Apply the fumigant from the outside of the bin whenever possible. Always have a second person nearby while fumigating. Use a self-contained breathing apparatus if you must enter the bin.
5. Always use the recommended dosage.
6. Keep all people and animals out of the building for at least 48 hours.
7. Never use fumigants when the grain temperature is below 60º F. During the cold winter months, it would be better to aerate, turn or move the grain.

FUMIGANT*	COMMODITIES	COMMENTS
Chloropicrin *RUP*	Empty-bin treatment only. (See comments on right.)	Chloropicrin is no longer registered for direct application to stored grain. However, the fumigant can still be used for treating the perforated floors in empty bins in order to control insects in the subfloor area prior to bin filling.
Aluminum phosphide ** *RUP*	Wheat, barley, rye, oats, corn sorghum, safflower seed, sunflower seed, soybeans, triticale and millet	Aluminum phosphide is available under trade names such as Fumitoxin, Weevil-Cide and Phostoxin in pellet or tablet form. Since phosphine gas is only slightly heavier than air, it is very important that the bins are tightly sealed and the grain surface covered with plastic sheeting after the fumigant has been probed into the grain mass. Since there is a delay time of 1 to 2 hours with tablets before dangerous amounts of phosphine gas are released, applicators can normally complete application before toxic fumes begin to develop in the bin.
Methyl bromide *RUP*	Wheat (similar small grain), shelled corn and milo (grain sorghum)	Methyl bromide can affect the germination of seeds at high moisture levels and high dosages. It is more than 3 times the weight of air, and recirculation techniques may be needed to ensure even distribution. This, plus the fact that methyl bromide is very hazardous to work with, are reasons that this product should only be used by trained professional fumigators.

RUP - Restricted use pesticides are to be applied by or under the direct supervision of certified pesticide applicators only.

*Dosage rates for the fumigants listed will vary depending upon the commodity and type of storage structure to be treated. Read and follow label directions carefully!

****Fumigation Management Plan**

- The certified applicator is responsible for working with the owners and/or responsible employees of the structure and/or area to be fumigated to develop and follow a Fumigation Management Plan (FMP). The FMP is intended to ensure a safe and effective fumigation. The FMP must address characterization of the structure and/or area, and include appropriate monitoring and notification requirements, consistent with, but not limited to, the following:
- Inspect the structure and/or area to determine its suitability for fumigation.
- When sealing is required, consult previous records for any changes to the structure, seal leaks and monitor any occupied adjacent buildings to ensure safety.
- Prior to each fumigation, review any existing FMP, MSDS, Applicator's Manual and other relevant safety procedures with company officials and appropriate employees.
- Consult company officials in the development of procedures and appropriate safety measures for nearby workers who will be in and around the area during application and aeration.
- Consult with company officials to develop an appropriate monitoring plan that will confirm that nearby workers and bystanders are not exposed to levels above the allowed limits during application, fumigation and aeration.
- This plan must also demonstrate that nearby residents will not be exposed to concentrations above the allowable limits.
- Consult with company officials to develop procedures for local authorities to notify nearby residents in the event of an emergency.
- Confirm the placement of placards to secure entrance into any structure under fumigation.

- Confirm the required safety equipment is in place and the necessary manpower is available to complete a safe and effective fumigation.
- Written notification must be provided to the receiver of a vehicle that is fumigated in transit.

These factors must be considered in putting an FMP together. It is important to note that some plans will be more comprehensive than others. All plans should reflect the experience and expertise of the applicator and circumstances at and around the structure and/or area. In addition to the plan, the applicator must read the entire label and Applicator's Manual and follow its directions carefully. The FMP and related documentation, including monitoring records, must be maintained for a minimum of two years.

REASONS FOR FUMIGATION FAILURES

Insufficient Fumigant: Because the efficiency of a fumigant depends on the maintenance of a killing concentration in the grain, any factor that affects gas concentration is important. You cannot get satisfactory results by applying less than the recommended dosage (a common problem). Be sure to use the amount of fumigant required for the capacity of the bin, not the amount of grain contained in the bin.

Storage Structure: A loosely constructed, leaky bin may not retain fumigants long enough to kill the insects while a tight concrete or metal bin may hold the fumigant in killing concentrations for several days. The depth of the grain in relation to its surface area also affects the efficiency of a fumigant. In general, the greater the surface area of the grain in proportion to the bulk, the greater the difficulties encountered in fumigation. This is the practical reason (except for leaks) that flat storages require higher dosages than round silo-type bins. Storage structures with a large amount of space over the grain are also difficult to fumigate effectively, as large amounts of gas escape into the head space.

Type of Grain and Dockage: The kind of grain affects the efficiency of a fumigant in accordance with its sorption quality. For example, shelled corn and grain sorghum appear to be much more sorptive than wheat. Wheat with dockage exceeding 3% requires nearly twice the dosage than wheat with less than 1% dockage requires.

Moisture: The moisture content of the grain has a profound effect on the efficiency of a fumigant - the higher the moisture content, the higher the dosage required. As the moisture content increases above 12%, a proportionally higher dosage is required. Generally you cannot satisfactorily fumigate grain having a surface moisture content of 15% to 20% because the fumigant vapors will not penetrate the moist layer.

Temperature: During fumigation the gas quickly assumes the temperature of the grain. An increase in temperature results in greater molecular activity of gases, which facilitates the diffusion and penetration of the fumigant. However, there are limiting factors for both extremes of high or low temperatures. If grain temperature reaches 115º F, the fumigants vaporize very rapidly and may escape from the bin before lethal gas concentrations can be obtained. Most stored grain insects cannot survive in grain at 115º F or above, thus eliminating the need for fumigating. You need not fumigate stored grain with a temperature of 60º F or below as the insects are inactive at this temperature.

INSECTICIDE PRICE LIST

The prices listed are approximate retail prices for dry ounces (oz), fluid ounces (fl oz), pounds (lb) or quarts (qt), depending on the product. Prices do not include costs of additives or application costs. Prices may vary depending on area of the state, wholesaler, bulk discounts, generic products in stock, seasonal changes, quantities purchased, and special offers. **Growers should consult their local agricultural product suppliers for current prices.** Only products for which prices could be determined are listed below.

Trade Name	Active Ingredient	Cost ($) per Unit
Acramite 4SC	bifenazate	2.38/fl oz
Actara	thiamethoxam	3.61/oz
Admire Pro	imidacloprid	1.66/fl oz
Agri-Mek SC	abamectin	2.58/fl oz
Asana XL	esfenvalerate	0.53/fl oz
Assail 30SG	acetamiprid	4.25/oz
Athena	abamectin bifenthrin	0.98/fl oz
Avaunt	indoxacarb	6.31/oz
Aztec 4.67G	cyfluthrin tebupirimiphos	0.50/oz
Aztec 4.67G Smart Box	cyfluthrin tebupirimiphos	0.56/oz
Baythoid XL	beta-cyfluthrin	2.58/fl oz
Belay	clothianidin	2.34/fl oz
Beleaf 50G	flonicamid	11.10/oz
Besiege	chlorantraniliprole lambda-cyhalothrin	2.31/fl oz
Bifender FC	bifenthrin	2.45/fl oz
Blackhawk	spinosad	6.54/oz
Brigade 2EC	bifenthrin	1.08/fl oz
Brigadier	bifenthrin imidacloprid	1.42/fl oz
Capture LFR	bifenthrin	2.48/fl oz
Centynal	deltamethrin	2.35/fl oz
Chlorpyrifos 4E AG	chlorpyrifos	0.25/fl oz
Clariva Elite Beans	thiamethoxam	4.91 fl/oz
Cobalt Advanced	chlorpyrifos lambda-cyhalothrin	0.47/fl oz
Coragen	chlorantraniliprole	7.27/fl oz
Counter 20G Lock n' Load	terbufos	0.28/oz
Counter 20G SmartBox	terbufos	0.28/oz
Cruiser 5FS	thiamethoxam	5.94/fl oz
Cruiser Maxx Cereals	thiamethoxam	0.65/fl oz
Cruiser Maxx Potato	thiamethoxam	6.41/fl oz
Cruiser Maxx Vibrance	thiamethoxam	5.00/fl oz
Cruiser Maxx Vibrance Cereals	thiamethoxam	0.88/fl oz
Cruiser Maxx Vibrance Potato	thiamethoxam	3.58/fl oz
Cruiser Maxx Vibrance Pulses	thiamethoxam	1.40/fl oz
Diacon II	methoprene	4.91/fl oz
Diacon D	methoprene	0.23/oz
Dibrom 8 Emulsive	naled	0.98/fl oz
Dimate 4E	dimethoate	0.34/fl oz
Dimethoate 400	dimethoate	0.34/fl oz
Dimethoate 4E	dimethoate	0.34/fl oz
Dimethoate 4EC	dimethoate	0.30/fl oz
Dimilin 2L	diflubenzuron	2.11/fl oz
DiPel DF	Bt	0.85/oz
Dyna-Shield Imidacloprid 5	imidacloprid	1.25/fl oz

Trade Name	Active Ingredient	Cost ($) per Unit
Endigo ZC	lambda-cyhalothrin thiamethoxam	1.76/fl oz
Ethos XB	bifenthrin	2.80/fl oz
Exirel	cyantraniliprole	3.52/fl oz
Fanfare 2EC	bifenthrin	1.03/fl oz
Fastac CS	alpha-cypermethrin	1.35/fl oz
Fastac EC	alpha-cypermethrin	1.03/fl oz
Foothold Extra	imidacloprid	1.10/fl oz
Foothold Virock	imidacloprid	1.10/fl oz
Force 3G	tefluthrin	0.40/oz
Force 3G SmartBox	tefluthrin	0.48/oz
Force Evo	tefluthrin	3.37/fl oz
Fulfill	pymetrozine	6.39/oz
Gaucho 600	imidacloprid	2.73/fl oz
Hero	bifenthrin zeta-cypermethrin	1.79/fl oz
Imidan 70W	phosmet	0.70/oz
Intego Suite Cereals OF	clothianidin	0.84/fl oz
Intego Suite Soybeans	clothianidin	3.89/fl oz
Intrepid 2F	methoxyfenozide	1.89/fl oz
Lambda-Cy EC	lambda-cyhalothrin	0.64/fl oz
Lannate LV	methomyl	0.63/fl oz
Leverage 360	beta-cyfluthrin imidacloprid	2.12/fl oz
Lorsban 15G	chorpyrifos	0.14/oz
Lorsban 4E	chlorpyrifos	0.43/fl oz
Lorsban Advanced	chlorpyrifos	0.43/fl oz
Malathion 5	malathion	0.29/fl oz
Malathion 57EC	malathion	0.23/fl oz
Movento	spirotetramat	8.16/fl oz
Movento HL	spirotetramat	11.19/fl oz
Mustang Maxx	zeta-cypermethrin	1.32/fl oz
NipsIt Inside	clothianidin	8.15/fl oz
NipsIt SUITE Cereals OF	clothianidin	0.68/fl oz
Nuprid 4F Max	imidacloprid	0.88/fl oz
Oberon 2SC	spiromesifen	2.87/fl oz
Permethrin 3.2EC	permethrin	0.45/fl oz
Perm-UP 3.2EC	permethrin	0.45/fl oz
Platinum	thiamethoxam	2.25/fl oz
Platinum 75SG	thiamethoxam	6.67/oz
Pounce 1.5G	permethrin	0.09/oz
Precept	tefluthrin	0.38/oz
Prevathon	chlorantraniliprole	1.14/fl oz
Radiant SC	spinetoram	6.83/fl oz
Rancona Crest	imidacloprid	1.17/fl oz
Rancona Crest WR	imidacloprid	0.97/fl oz
Raxil Pro Shield	imidacloprid	0.93/fl oz
Regent 4SC	fipronil	9.12/fl oz
Rimon 0.83EC	novaluron	1.84/fl oz
Sefina	afidopyropen	2.05/fl oz
Senator 600FS	imidacloprid	2.86/fl oz
Sevin 4F	carbaryl	0.38/fl oz

Trade Name	Active Ingredient	Cost ($) per Unit
Sevin XLR Plus	carbaryl	0.42/fl oz
Silencer	lambda-cyhalothrin	0.45/fl oz
Silencer VXN	lambda-cyhalothrin	0.54/fl oz
Sivanto Prime	flupyradifurone	2.70/fl oz
Skyraider	bifenthrin imidacloprid	1.24/fl oz
Sniper	bifenthrin	0.84/fl oz
Sniper Helios	bifenthrin	0.84/fl oz
Sniper LFR	bifenthrin	1.41/fl oz
Stallion	chlorpyrifos zeta-cypermethrin	0.79/fl oz

Trade Name	Active Ingredient	Cost ($) per Unit
Steward EC	indoxacarb	2.03/fl oz
Thimet 20G Lock n' Load	phorate	0.25/oz
Tombstone Helios	cyfluthrin	2.15/fl oz
Transform WG	sulfoxaflor	7.37/oz
Venom	dinotefuran	7.48/oz
Vydate C-LV	oxamyl	0.88/fl oz
Vydate L	oxamyl	0.59/fl oz
Warhawk	chlorpyrifos	0.34/fl oz
Warrior II	lambda-cyhalothrin	2.65/fl oz
Zeal SC	etoxazole	6.82/fl oz

The printing cost for this publication was paid for in part by fees paid by certified North Dakota Pesticide Applicators and Dealers.

For information regarding pesticide certification, contact the **North Dakota State University Extension Pesticide Program**

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Fax: 701-231-5907
Email: NDSU.pesticide@ndsu.edu
www.ndsupesticide.org

For pesticide enforcement, compliance assistance, registration, and other regulatory issues, contact the **Agriculture Chemical Division at the North Dakota Department of Agriculture**

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10M-11-18, 10.75M-12-19