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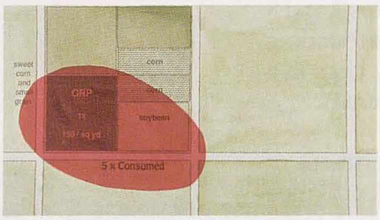
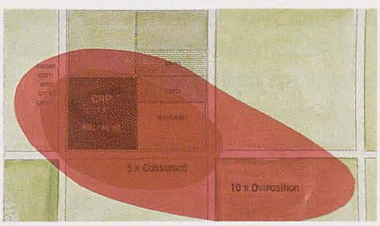


Grasshopper Management

David M. Noetzel



About the Cover

Photos describe an actual situation in Minnesota. A quarter section of CRP land in 1988 contained 150 twostriped grasshoppers per square yard. Removal of the forage on the CRP increased the dispersal of the grasshoppers so that between 400-500 surrounding cropland acres were consumed (see damage pictures 7 and 8 on pages 4 and 5). After destroying the surrounding crop, the adult grasshoppers continued to lay eggs in a 2,000 acre area (photo with larger shadowy area).

Picture credits: David Walgenbach, Department of Plant Science, South Dakota State University, provided Pictures 4, 5, and 6.

David M. Noetzel is an extension entomologist and a professor, Department of Entomology, University of Minnesota.

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GRASSHOPPER MANAGEMENT

David M. Noetzel

Grasshoppers and locusts, worldwide, are generally associated with grasslands, semi-arid and/or arid lands (10-20 inches rainfall per year). Such varied geographic areas have two things in common in abundance and "outbreak" frequency of grasshoppers and/or locusts: first, permanent undisturbed soil and second, dryness. Undisturbed soil sites are preferred by grasshoppers for egg laying while egg and nymph survival is much higher when soils are dry.

In North America the last migratory grasshopper swarms were reported in the 1870s. Between then and now no truly migratory grasshoppers have been collected. However a major grasshopper outbreak did occur over much of central North America during the 1930s. Since the 1930s grasshopper outbreaks have been much more geographically restricted and more associated with permanent sites such as grassland, rangeland, and pasture and/or roadsides.

Until the 1986-89 increase, Minnesota had not experienced a major grasshopper outbreak since the 1930s. However, Minnesotans have had to deal annually with lower level populations which commonly move from maturing small grain and grasses to row crops.

Major Kinds of Cropland Grasshoppers

Of some 75-100 kinds of grasshoppers in the northern Great Plains only four or five are important crop damaging species. There are a number of illustrated keys (grasshoppers pictured in technical books) one can use to positively identify them. However, because grasshopper management in Minnesota is largely related to crop protection, early monitoring of the crop will permit sound control judgments even without positively identifying the grasshopper involved.

Twostriped Grasshopper (Picture 1)

This is normally the first grasshopper to hatch in Minnesota. The adult is a grayish or brownish green grasshopper with two distinct yellow stripes one on each upper-outer edge of the thorax and wings, and extending from the head to the wing tips. The jumping legs have a distinct black dorsal band on an otherwise yellow femur. Adult size ranges in length from 1 1/4 to nearly 2 inches. Egg laying begins early in July. It is a grass-loving (small grain) grasshopper. Because of this early egg laying, nymph development is often completed within the egg shell in the fall. When eggs have reached the "eyespot" stage, it means completion of embryonic development. Completion of embryonic development in the fall permits the early spring hatch.

Migratory Grasshopper (Picture 2)

This is the earliest appearing medium-sized (approximately 1 inch long) grasshopper which moves to crops. It probably does better in native prairie habitat than any of the five cropland pests. Its color is brown to gray with a distinctive black mark behind its compound eyes. In the field it is readily confused with the red-legged grasshopper. There is a slight hump behind the spine on the bottom of the hopper between the middle leg pair which can distinguish it from the redleg. It has strong flight tendency although it has not shown long distance migratory behavior recently.

Clearwinged Grasshopper (Picture 3)

This hopper is slightly smaller than either the migratory or redlegged grasshopper. It is very light tan to brownish and the wings are usually distinctly marked with relatively large brown spots. It is about 3/4 inch long and can be fairly successful in native locations.

Redlegged Grasshopper (Picture 4)

Adults are from 3/4 to 1 inch long and brownish red. Its name comes from the commonly pinkish-red tibia on the jumping legs. The tibial spine is very dark. It should be observed, however, that reddish-pink tibia occur on other hoppers and bluish tibia are frequent in redlegged populations.

Redlegged adults show marked preference for oviposition especially in alfalfa. Much higher numbers of nymphs exist in Conservation Reserve Program (CRP) areas heavily in alfalfa and in commercial alfalfa fields. High numbers have not been observed in any brome grass roadside or in grassy CRP.

Differential Grasshopper (Picture 5)

The adults are yellowish or greenish gray without stripes or markings on the thorax or wings. The jumping legs are marked with distinct black chevrons on the outside of each femur. Indeed the older name for this grasshopper was the "Sergeant" hopper. Adults are large—1 1/2 to 1 3/4 inches long—and, in high numbers, can contribute a remarkable amount of damage late in the season.

Differential hopper adults are seasonally last to develop in Minnesota. They are much more abundant in south and southwest Minnesota than in the central and north.

Life Cycle (Picture 6)

Female grasshoppers with a four pronged digging device on the tip of their abdomen dig a small burrow in firm soil—picture 6—(CRP, roadsides, pastures, soybean, small grain stubble, etc.) Eggs are laid in groups of from 4 to 40 per burrow. The eggs are usually cemented together, and covered with a cement layer which has soil particles strongly attached. These egg masses are located from 1/2 to 2 inches below the soil surface. A female can lay up to 25 egg masses depending on the kind of grasshopper and its nutrition. All of the cropland grasshoppers winter in the egg stage.

With normal temperatures, egg hatch of the twostriped grasshopper begins in late April and early May. The peak of hatch depends on the kinds of grasshoppers in the area (figure 1) but typically occurs mid- to late-May for twostriped grasshoppers and perhaps two weeks later when considering all five kinds of grasshoppers.

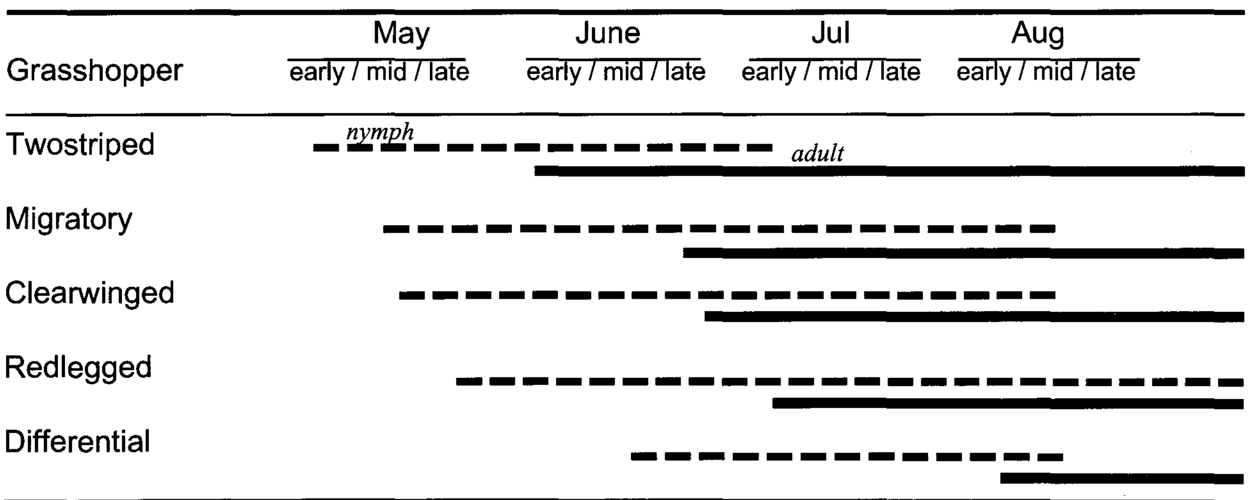
Young grasshoppers are called nymphs. There are five nymphal stages (figure 2) with an occasional auxiliary stage. The nymph grasshopper can be readily recognized as a wingless grasshopper. The size and shape of these developing wings are used to determine the nymphal stage as wing condition changes with each of the 5 or 6 nymphal molts. The nymphal stages are completed in from 40 to 60 days per individual grasshopper.

Above normal mortality in the egg and/or nymphal stage usually ends on outbreak. Probably the biggest single factor for increased egg mortality is increased soil moisture. Normal rainfall (20 plus inches) is certainly detrimental to grasshopper population increase due both to poor egg and nymphal survival. Severe drought is also detrimental to egg survival for the species of grasshoppers discussed here.

When devising control strategies, remember that nymphs are wingless and can only move a few yards by jumping. For example, fields planted after soybeans must be carefully monitored in areas where adult grasshopper numbers were high the previous fall as egg laying can take place in soybeans. Thus a high population of nymphs can occur in the crop following beans.

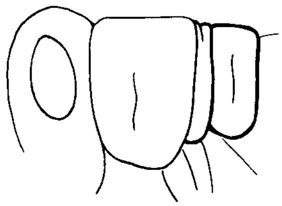
The winged adults have enormously more mobility than the nymphs. If nymph and adult populations are high so the food on the oviposition site is depleted (or if the food is removed through haying, for example) rather dramatic movement of both nymphs and adults onto

Figure 1. Summer phenology of 5 major cropland grasshoppers in Minnesota



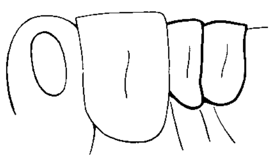
Melanoplus bivittatus=2striped
M. sanguinipes=migratory
M. femurrubrum=redlegged
M. differentialis=differential
Camnula pellucida=clearwinged

Figure 2. Distinguishing characteristcs of grasshopper nymphal stages*



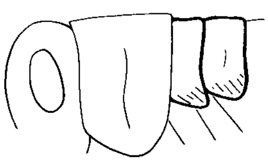
First instar nymph

Fourth instar nymph

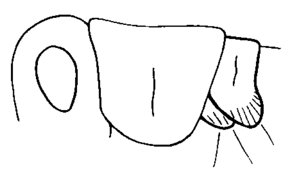


Second instar nymph

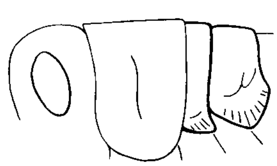
Fifth instar nymph



Third instar nymph

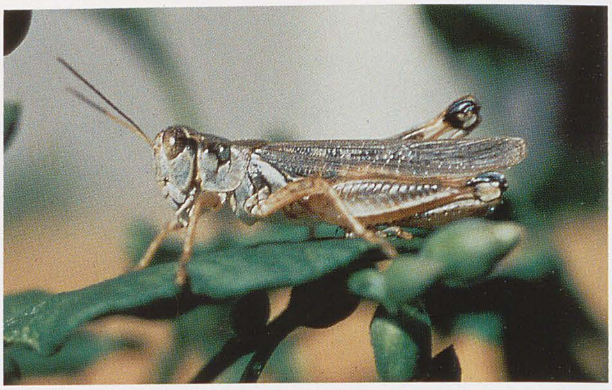


Extra instar nymph



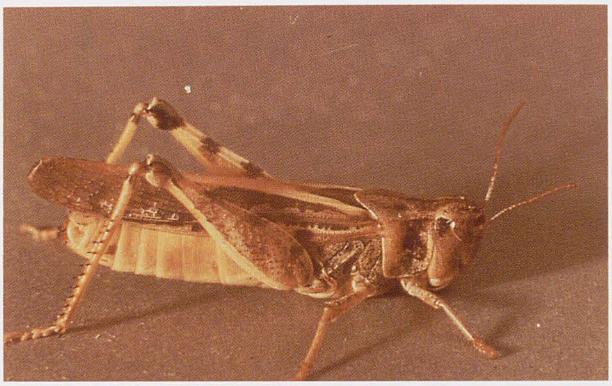
Third instar nymph

*From: Grasshoppers (Acrididae) of Colorado—1982 by J.L. Capinera and T.S. Sechrist. Colorado State University Experiment Station, Fort Collins, Bulletin No. 584S.



Picture 2. Migratory Grasshopper

Picture 1. Twostriped Grasshopper



Picture 3. Clearwinged Grasshopper

Picture 7. Grasshopper Damage in Soybeans (1988)

Picture 4. Redlegged Grasshopper

Picture 5. Differential Grasshopper

Picture 6. Grasshopper Ovipositing

Picture 8. Grasshopper Damage in Corn (1988)

adjacent croplands occurs. It is virtually impossible to protect a crop under such conditions.

Damage (Pictures 7, 8)

Grasshopper damage to crops consists of defoliation and direct feeding injury to pods and/or seeds. In estimating yield reductions use normal defoliation tables for corn, soybean, sunflower, etc. Normally an action level of 8 grasshopper adults per square yard is used for protecting the crop. However economic injury has been observed in soybean with fewer than 8 adult twostriped grasshoppers per square yard. When monitoring any crop for grasshopper damage be sure to go beyond visible defoliation by bending plants over and examining pods, etc.

Damage by grasshoppers occurs most often on cropland borders. When grasshoppers are small, or adult numbers are low, then crop protection can be achieved with border treatments of the crop. However if nymph numbers are very high or if adult numbers are moderate to high (more than 8 per square yard) then border applications of the crop may provide inadequate grasshopper control.

Migration of grasshoppers from small grain to row crops is common even during seasons when grasshoppers are not present in large numbers. In those seasons application to field borders will suffice.

Estimating Grasshopper Populations

Before any biological, cultural, or chemical control is considered, grasshopper population estimates are essential. There are two basic methods of doing this.

The first is through an egg survey. Because the eggs are deposited in the upper 1 or 2 inches of soil this soil can be sifted through a 1/4-inch hardware cloth, being careful to keep egg pods intact. Averaging counts from a number of square foot samples, representatives of the location and a number of representative sites, was believed to represent general grasshopper population trends. For years states surveyed in this manner using standard sampling patterns in cooperation with USDA Animal and Plant Health Inspection Service (APHIS). However analysis of these data showed that predictability of the following seasons grasshopper numbers from fall egg counts was rather poor (correlation—less than .2).

Because egg counts in the spring are more difficult and less reliable than counting nymphs, it is well to spend time monitoring and surveying for nymphs.

Nymph and Adult Sampling

Surveys of nymphs and/or adults save time and allow judgments more likely to assure there will be economic benefit from control. Thus, this surveying is clearly the best pest management procedure to follow.

Grasshoppers do not just "happen all of a sudden." Their numbers build up over three or more years so that the earliest season nymph surveys should be carried out where "hot spots" were experienced the previous seasons. These spring nymph surveys can begin in late April or early May, will continue through June and even into July some seasons.

Late, warm falls followed by warm, dry springs will advance the hatch while opposite weather conditions will delay the hatch.

Suggested action levels (table 1) are standard for the United States. It is fairly straightforward to walk through an area and count the grasshoppers which jump or move within a square foot. Divide these square foot counts by how many are taken and multiply by 9. This will give hoppers per square yard. Big differences (8 vs. 50 hoppers per square yard) are very easy to determine. It will be harder to differentiate between 8 vs. 10 per square yard. Control will generally be necessary when square yard counts reach the threatening level.

Table 1. Grasshopper nymph and adult ratings based on numbers/square yard

Rating	Nymphs per square yard		Adults per square yard	
	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	29

These guidelines are not absolute and must be modified depending on the kind of grasshopper, the crop condition, and crop value. Obviously nymph damage changes considerably as nymphs grow. For example, no grower or crop can tolerate 45, 4th or 5th stage twostriped or differential nymphs per square yard.

NATURAL ENEMIES

All stages of grasshoppers are attacked by one or more types of organisms. The effectiveness of most of these depends on hopper populations and environmental conditions. Researchers have compiled a large research base for some organisms which cause grasshopper mortality while other organisms have not been critically or intensively studied.

Protozoans

Perhaps the best known of these well-studied, natural enemies is a Sporozoan named (*Nosema locustae*). This disease is normally present at low incidence in many grasshopper populations but does not normally lead to natural epidemics nor significant natural mortality. *N. locustae* spores are incorporated on bran baits which have been applied both by ground and aerial equipment. These must be applied early in the season so that young hoppers consume them. This raises the *Nosema* infection rate in the grasshopper population. As some nymph mortality takes place the disease incidence in the hopper population is further raised through live hoppers consuming dead, diseased carcasses. The disease is also transmitted through the egg to young nymphs. Data show *N. locustae* has value in areas where crop value is low. It acts slowly and does not always provide sufficient mortality to preclude the use of an insecticide to protect a (high value) crop. Commercial baits of *N. locustae* have been produced and marketed under various names but all have struggled to become economically viable.

Fungi

There is also much interest in a fungus, *Entomophagus grylli*, which often causes locally high mortality. Grasshoppers infected with this fungus usually climb up on the plant and grasp the plant tightly with the grasshopper head upward. The diseased hopper has a sort of brownish to dark appearance. Its dead body is filled with fungal spores. As the grasshopper body disintegrates the spores are disseminated so that healthy grasshoppers can contact the sticky spores. The spores stick to the healthy hopper, germinate, and the fungus penetrates the new host. There is much interest in more virulent races of this organism. It is not commercially available yet.

Parasites

Parasites of grasshoppers include nematodes, mites, and insects. Nematodes, called threadworms or hair worms, commonly infest adult grasshoppers. These will be most often observed when the grasshopper is squashed or stepped on. These generally reduce the vigor of, or sterilize the grasshopper but are not considered large mortality factors.

Insects, especially flies, can parasitize the nymph or adult insect. Some wasps are capable of parasitizing grasshopper eggs. None of these has been shown to cause large mortality.

Mites are commonly attached to the wings, thorax, and abdomen of the grasshopper. These are usually bright red and very conspicuous. However, these have not been demonstrated to bother the grasshopper to any extent.

Predators

Arthropods, birds, and mammals all consume grasshoppers. Grasshopper eggs are eaten by crickets, ground beetles, and by larvae of blister beetles and bee flies. Spiders, wasps, robber flies, rodents, and birds eat both nymph and adult grasshoppers. Generally predator populations that depend on grasshoppers increase in number after grasshopper populations increase. Blister beetle and bee fly population increase as a result of grasshopper population increases. There is no effective use of predators in field control of grasshoppers.

CULTURAL CONTROL

Effect of tillage on grasshopper populations

Tillage will affect the distribution of grasshopper egg deposition. Grasshoppers usually prefer to oviposit in undisturbed sites such as roadsides, pasture, CRP, and weedy fallow. Egg laying in soybeans and in uncultivated, or untilled, small grain stubble is also fairly common during outbreaks.

Obviously, roadsides and CRP are not subject to tillage. Likewise it is not possible to till row crops early enough to interfere with grasshopper egg laying. However, weedy fallow and small grain stubble can be tilled early enough to greatly reduce grasshopper egg laying in those locations. In fact normal tillage practices which almost immediately follow small grain harvest disturb stubble enough so that it is virtually free of eggs.

Weedy fallow is attractive to grasshopper egglaying, both because the weeds attract hoppers and the soil is firm. If the weeds are removed or if the fallow is disturbed (which removes most weeds), the weedy fallow becomes extremely unattractive to grasshopper egg laying.

Tillage following egg laying is quite another matter. Generally the deeper the eggs are buried as a result of tillage, the fewer nymphs emerging the following spring. However "egg mortality," even when deep plowed, is rarely if ever, high enough to deal with other than marginally economic numbers. So, if 100 grasshopper eggs are counted per square yard with tillage, it would take killing 92 eggs to get below the 8 hoppers per square yard considered an action level. *Even deep plowing does not consistently kill such large numbers of grasshopper eggs.*

To summarize:

• Tillage prior to, or early in, oviposition in small grains or weedy fallow will reduce or stop egg laying in such sites.

• Tillage following egg laying will not normally reduce grasshopper numbers the following season to below economic levels on that site.

• As a result other justifications for tillage method (erosion control, moisture retention, etc.) far exceed any perceived benefit in insect control.

• This is nearly universally true with all insects that lay eggs or pupate in the soil, or that pupate in plant debris subject to tillage.

• Stepped up tillage (beyond what is already being done) will not affect long term fluctuations in insect populations in any measurable way.

Chemical Control

A number of basic considerations need to be recognized before a chemical control is applied.

1. Crop protection is the primary goal.
2. Grasshopper numbers must be high enough to warrant control.
3. External values such as human safety, wildlife, water quality, and insecticide effects on non-target organisms need strong consideration.
4. There is no evidence for long term reduction of grasshopper numbers with insecticide. Insecticide use is only justified as current crop protection—not effective on next year's grasshoppers.
5. Treat in a manner that:
   a. reduces number of applications,
   b. reduces dosage,
   c. but prevents oviposition to the greatest extent possible.
6. Use insecticides according to label instructions.

CONTROL STRATEGIES

Overall Objective

The overall objective is to obtain maximum pest reduction, or crop protection at a minimum cost. Cost includes application costs but also the external costs such as human risk, wildlife hazard, risk to water quality, and risk to other non-target organisms. It is difficult to place dollar values on many of these risks but assuming that reducing the need for application will speak to these external values suggests: treat only when needed. If treatment is needed, then the fewest applications and the least dosage should also serve to reduce total cost with no negative effect on benefits.

Early Season Control Strategy

During years (such as 1988) when populations of young grasshoppers (nymphs) are high enough to cause crop damage to, for example, sugarbeet and small grain, protective applications will have to be made, at least to borders of the crop in late April and early May. More extensive treatments, if necessary, may have to be made to protect the crop stand. At some point (150 nymphs per square yard) the area requiring treatment may have to be expanded from crop to roadsides, CRP, and other idle land. Proceed cautiously, however, because if 1st through 3rd stage nymphs are being found, the hatch is incomplete and additional applications may be required later. Do not treat blocks of land where nymphs are abundant until a portion of the grasshopper population is in the 5th stage.

Roadsides should not normally be treated until late stage nymphs (5th stage) become present. Crops adjacent to heavily infested roadsides may often require protection earlier, but properly timed roadside application should permit a single insecticide application for season-long control. Roadsides adjacent to larger sources (e.g., CRP) of grasshoppers cannot be protected to any great extent from hopper migration.

Late Season Treatment

Grasshopper adults (twostriped) will begin to show up by mid-June. Where twostriped grasshoppers are dominant, control on the larger production sites (e.g., CRP, roadsides, etc) needs to begin just prior to mid-June so that grasshoppers cannot mate and lay eggs for the next season. More important, becoming winged leads to an enormous increase in mobility. Applications to the crop to protect against inward migration of adult grasshoppers where hopper numbers are high had rather limited effectiveness. Even repeated applications will not completely protect the crop.

In 1988 CRP was cut for hay about mid-June coinciding closely with the beginning maturation of the grasshopper population. The best strategy for cutting would have been to leave wide strips (10-20 yards) uncut to which resident hopper populations could have migrated and then to spray the strips.

Where populations of hoppers are high (100 plus per square yard) and there is a need to cut the hay, it would be better to treat with an insecticide with a short preharvest interval prior to cutting the hay.

In suggesting control strategies it is not possible to perfectly prescribe what needs to be done in a specific situation. In general, border cropland early when nymphs are small and nymph numbers are moderate. If nymph numbers are high early, it may be necessary to border both crop and grasshopper production site (e.g., CRP, roadside). As nymphs become larger move treatment to the production site and enlarge the treated portion of the production site to handle the numbers of grasshoppers present. When 100 or more grasshoppers per square yard are present on a production site, it is usually much cheaper and more environmentally safe to treat the production site rather than make repeated applications to adjacent cropland.

SELECTION OF INSECTICIDES FOR GRASSHOPPER CONTROL

All labeled sites for grasshopper control are listed either in table 1 or table 2. The specific site must be on the label or the product should not be used on that site. For example, neither Lorsban nor Furadan has a roadside or non-cropland label. Sevin XLR plus does not have a non-cropland label but does have a specific roadside designation. If the intent is to harvest roadside or CRP for forage, then an insecticide such as Sevin XLR plus or malathion should be used on the site.

CRP is designated by the Environmental Protection Agency (EPA) as being a crop so non-cropland labels cannot be used on CRP, according to EPA. The Minnesota Department of Agriculture however, has indicated products labeled for use on pasture and rangeland can also be used on CRP.

Asana XL labels for use on wheat and CRP came through a Section 18 or Crisis Exemption granted by the Minnesota Department of Agriculture. Roadside uses of Asana XL, or any other insecticide, are permitted through the non-cropland site label. Currently Asana XL-treated plant material cannot be used for forage.

Table 1. Insecticides presently labeled for grasshopper control, label sites (except CRP), recommended dosages and preharvest intervals

Insecticide and formulation	Site													
	Alfalfa		Corn		Soybean		Wheat		Pasture		Range		Non-crop	
	dosage	*phi*	*dosage*	*phi*	*dosage*	*phi*	*dosage*	*phi*	*dosage*	*phi*	*dosage*	*phi*	*dosage*	*phi*
*Asana XL.66E	-	-	5.8-9.6 fl oz	21	4.8-9.6 fl oz	21	-	-	-	-	-	-	2.4-4.8 fl oz	-
Dimethoate 4E	1/2-1 pt	10	2/3-1 pt	14	1 pt	21	3/4 pt	60	-	-	-	-	-	-
Diazinon 4E	1 pt	7	1 pt	0	-	-	-	-	3/4-1 pt	0	3/4-1 pt	-	3/4-1 pt	-
*Ethyl 8E parathion	1/2 pt	15	1/2 pt	12	1/2 pt	20	1/2 pt	15	-	-	-	-	-	-
*Furadan 4F	1/4-1/2 pt	7	1/4-1/2 pt	30	1/4-1/2 pt	21	1/4-1/2 pt	-	-	-	-	-	-	-
Lorsban 4E	1/2-1 pt	7-14	1/2-1 pt	35	1/2-1 pt	28	-	-	-	-	-	-	-	-
Malathion 5E	1 1/2-2 pt	0	1 1/2 pt	5	1 1/2 pt (not for hopper)	-	1/2 pt	7	1 1/2-2 pt	0	1 1/2-2 pt	0	1 1/2-3 pt	0
ULV	8 fl oz	0	8 fl oz	5	8 fl oz	7	8 fl oz	7	8-12 fl oz	0	8-12 fl oz	1	8-12 fl oz	0
Orthene 75SP	-	-	-	-	1/3-2/3 lb	14	-	-	1/8-1/6 lb	21	1/8-1/6 lb	21	-	-
*Penncap-M 2F	1-3 pts	15	1-3 pts	12	1-3 pts	20	1-3 pts	15	1-3 pts	20	1-3 pts	15	-	-
*Scout .3E	6.4-8 fl oz	21	-	-	6-7 fl oz	21	-	-	-	-	-	-	-	-
Sevin XLR 4F	1-3 pts	7	1-3 pts	0	1-3 pts	0	1-3 pts	21	2-3 pts	0=air 14=ground	1-2 pts	0	-	-

*Restricted use compounds.
Diazinon - Ditch banks, roadsides, wasteland, barrier strips; Orthene - Wasteland; Malathion - Grass, grass hay
Sevin XLR - Wasteland, rights-of-way, hedgerows, ditch banks, roadsides; Penncap M - Roadsides, grass seed

Table 2. Insecticides labeled for use on grasshoppers in CRP, their dosages and limitations

Insecticide and formulation		Pints, lb or oz per acre	Limitations, preharvest interval
Diazinon	4E	3/4 - 1 pt	0 phi
Malathion	5E	1 1/2 - 2 pt	0
Malathion	ULV	8 - 12 fl oz	0
Orthene	75W	1/8 - 1/6 lb	21
*Penncap-M	2F	1 - 3 pts	20
Sevin XLR	4F	1 - 3 pts	0

*Restricted use compound.
In addition to the above, Asana XL can be used on non-cropland with the exception of public lands such as parks, forests or recreational areas. According to law the applicator should have the Sec. 18 label in hand and the applicator needs certification. The section 18 runs until August 15.

Wildlife Considerations

Table 3 provides comparative toxicities. Although there is some difference of opinion about wildlife risks from methyl and ethyl parathion, Furadan, diazinon, and Lorsban, this author discourages use on lands where wildlife production is a major consideration. Solid evidence is now available that ethyl, and possibly methyl, parathion at 1 pound actual insecticide per acre can cause duckling mortaility when directly applied by air to exposed ducklings. Exercise care with all insecticides around potholes, other open water, and drainage ditches. If it is necessary to treat where there is open water, at present the best insecticide choice would appear to be Sevin XLR plus and application to, or drift into, water should be strictly avoided..

CRP and roadsides which are known to be wildlife production areas as well as prime grasshopper egg locations should be monitored so that only single insecticide applications are required. Asana XL, Sevin XLR plus, and malathion are the products of choice for these two locations.

Honey Bees

Data on honey bee toxicity of the eleven grasshopper insecticides appear in table 3. These values are taken from Adkin's and Anderson's summaries. This author (Noetzel) thought that Asana XL and malathion (5E in water) would be relatively harmless to honey bees. During 1989, however, severe bee kills were observed where applicators indicated only Asana XL was used.

These kills occurred, however, where applications were probably repeatedly made to foraging bees. Similarly colony kills happened where malathion was the major insecticide used. No current insecticide appears safe for honey bees when spraying is widespread and repeated.

The management of grasshopper control, if it is to reduce bee kills, has to involve timing of treatments, moving colonies, or the screening colonies, or perhaps combinations of all three.

Early morning application (5:30 a.m. - 9 a.m.) and possibly late evening will largely avoid direct application on foraging bees. Early season monitoring of grasshopper populations and good communication between applicator and beekeeper should allow treatment of a fair amount of the area where grasshoppers are abundant and bees are foraging.

Where a larger block (1 or 2 sections) may need treatment, it may be necessary to screen the bees or make some other manipulation that will confuse the bees for a day or two.

Where still larger blocks (more than 2 sections) require treatment, the bees should be moved to avoid the conflict.

Always keep everyone concerned informed of grasshopper numbers, bee colony locations and applicator intentions. This responsibility is best mutually shared locally.

Table 3. Insecticides presently labeled for grasshopper control and their toxicities to selected organisms

Insecticide and formulation	Oral LD_{50} in mg/kg		96 hr LC_{50} (mg/L)	
	Rat (ie.man)	Birds	Blue Gill	Honey Bee
*Asana XL .66E	325**	>2250d***	.00046	Relatively non-toxic
Dimethoate 4E	215	20	6	Highly toxic
Diazinon 4E	250	4	168	Highly toxic
*Furadan 4F	8	4	240	Highly toxic
*Ethyl 8E parathion	4	12	24	Highly toxic
Lorsban 4E	97	8	2.4	Highly toxic
Malathion 5E	1000	167	103	Mod. toxic
ULV	1000	167	103	Highly toxic
Orthene 75SP	866	234d	<1000	Highly toxic
*Penncap-M 2F	9	8	4380	Highly toxic
*Scout .3E	2804	2510 quail	<4	Relatively non-toxic
Sevin XLR 4F plus	850	2000	6760	Highly toxic

*= Restricted use compound.
** = The larger the number the more safe the compound.
***d = mallard duck, otherwise pheasant.