

Bulletin 233

June, 1917

The Agricultural Experiment Station
OF THE
Colorado Agricultural College

GRASSHOPPER CONTROL

By
CHARLES R. JONES



A field demonstration of mixing and application of Paris green-bran mash, conducted on the premises of Mr. Turner, grasshopper campaign, 1916, San Luis Valley (Original).

PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
1917

The Colorado Agricultural College

FORT COLLINS, COLORADO

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GRASSHOPPER CONTROL

By CHARLES R. JONES

The agricultural interests of the United States have suffered for many years from the depredations of locusts, or grasshoppers, and every farmer should be more familiar with the methods of control. Usually the question of grasshopper control becomes a problem for concerted action, but co-operation is not always possible and the individual farmer should at all times keep this problem before him for consideration. In almost every county of Colorado there have been outbreaks of this pest, and various remedial measures have been applied. Should weather conditions favor insect development this year, practical control methods should be used to save the crops.

The past season witnessed several outbreaks in various parts of our State which were successfully controlled, and there is no longer any reason why the farmers should allow their crops to be destroyed by this pest. They are better informed than ever before as to the life history and habits of the grasshopper and the most efficient methods of destroying them. Colorado's "Amended Pest Law" provides for the forming of pest districts for the control of rodents and injurious insects, and can be applied effectively in all localities. This measure should have the active support of all county commissioners to give a basis for a county-wide organization, and the direct application of remedial measures for the complete control of this invading pest.

The general life history, habits, and practical methods of control of grasshoppers have been worked out and are given here, in order that the farmers may intelligently and successfully combat the pests. The investigations upon which this paper is based gives information that can be applied in any part of the State.

LIFE HISTORY

Egg.—The life histories of our various species of destructive grasshoppers are very similar. The female usually selects a spot to oviposit in some waste land. Ideal places are found along fence borders, ditch-banks, roadsides, weedy patches or fallow lands. Cultivated fields are not so susceptible to oviposition as the above mentioned places. The individual spot selected is generally slightly elevated, dry and somewhat protected from the sun.

After selecting a suitable place, the female forms a hole by forcing the tip of her abdomen down into the soil, and alternately

opening and closing the four horny processes at its tip. The depth of the hole depends upon the texture of the soil and the length of the abdomen of the hopper in question, the eggs being deposited between one-half and one and one-half inches from the surface. Upon completing this operation, the female deposits her eggs (Plate 1, Fig. 1), beginning at the bottom and gradually laying them singly and obliquely across the hole, at the same time covering the entire mass with a frothy mucilaginous substance which is secreted from the abdomen and forms a protective covering against dryness, excessive moisture, and, possibly, parasites.

All our injurious grasshoppers pass the winter in the egg stage. Active oviposition commences about the middle of August and extends thru the remaining warm days of fall, at least to the middle of November. Hatching begins in the following spring with the advent of the warm days of May and early June, and continues over an extended period, there being a great variation in time of hatching, as in oviposition.

The number of eggs laid varies with the species, generally ranging from 40 to 120. There are usually two egg-clusters deposited by the same female.

The individual eggs are cylindrical, about three- to four-sixteenths of an inch in length, curved slightly, and of a yellowish color. (Plate 1, Fig 2.)

Nymphs.—Upon hatching, the young hoppers, or nymphs, readily force their way to the surface of the soil thru the protective covering of the egg mass. The young hoppers closely resemble the adult, except that they are wingless and the head is very large and out of proportion with the rest of the body. They are very pale in color at first, but soon take on the coloration of their surroundings which, together with their small size, makes them very inconspicuous.

After hatching, the nymphs remain grouped for a day or two, but they soon develop ravenous appetites and begin feeding upon any green herbage. They do not feed at night, but usually crawl upon some grass stem or other object, where they remain until it begins to warm up the following day.

During the process of development, the nymphs molt a series of times, each successive skin being larger than the preceding one, and it is in this manner that the insect grows. When ready to molt, the hopper ceases feeding, crawls on some grass stem or other object, and fastens itself thereto by its hind claws, head downward. Thus it hangs motionless for several hours. The thorax or middle part of the body gradually swells until the skin splits down the

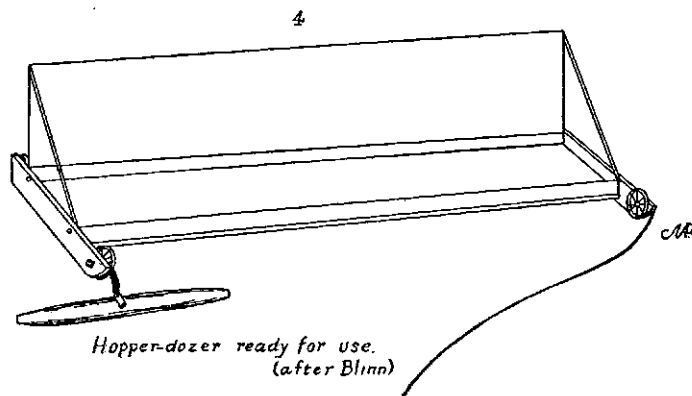
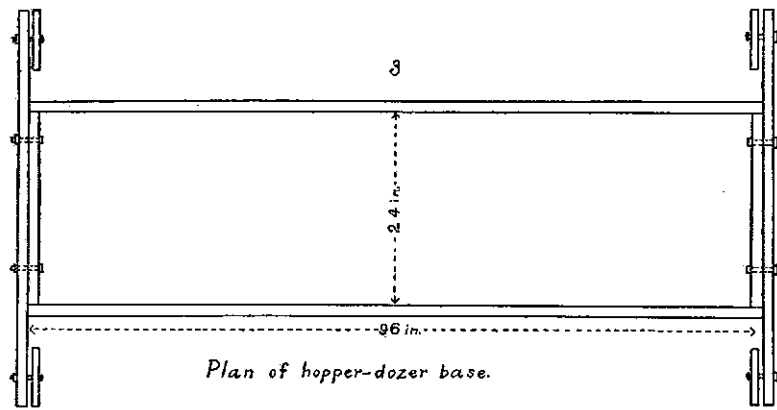
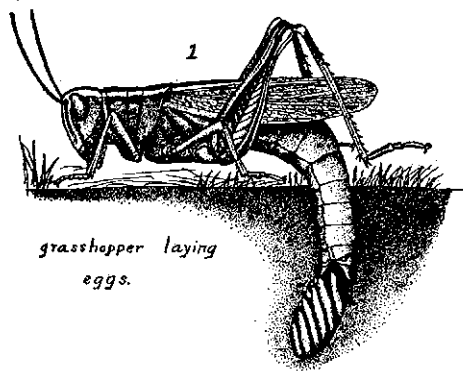


Plate I

back. Then by a series of muscular contractions, the body of the insect is gradually worked out of the old skin. The nymph usually clings to the old skin for a short time until the tender new skin becomes dry and sufficiently hardened for it to be able to move about.

The time required for the nymph to reach maturity, that is, to gain its wings, is from 60 to 90 days, depending upon the climate and locality. During this period, there are generally five molts.

While this pest is in the nymphal stage, the farmer should endeavor to eradicate or control it, as its only means of locomotion is by hopping, and the methods and application of remedial measures require less labor and materials, as the insects cannot escape by flying to uninfested or untreated areas, as they will do when maturity is reached.

Adults.—At the fifth molt, the wings of the hopper, which have been mere pads, become fully formed. When ready to transform from the nymph to the adult stage, the young hopper climbs to some upright object and remains, as in the preceding molts, motionless until the old skin is shed. The wings, which have been represented in previous molts by mere pads, now come into evidence, and after they are thoroly dried, which is usually before nightfall, the hopper is ready to fly.

Climatic conditions affect the adults in the same manner as the nymphs. They are very active during the warm, sunny days, and are sluggish and quiet during cold, wet weather.

Egg Laying.—After the adult stage has been reached, which varies considerably, owing to variation in egg laying, oviposition and rate of development in individuals of the same brood, the females feed for a week or two, during which time they develop a mass of eggs and then oviposition takes place. The places selected will extend over a considerable area of ground in such places as before mentioned.

FOOD HABITS—PLANTS AFFECTED

Unlike most other insect pests which attack plants of an economic value, the grasshoppers are able to exist upon almost any green herbage, in most cases attacking the tender, succulent growth of the plant in question. In our irrigated sections, young alfalfa affords an ideal food for them, as well as young small grains, corn, field peas, and any garden or truck crop. Deciduous trees do not escape the ravages of this pest. Orchard trees, roses in the flower gardens, and even willows along ditch banks suffer severely at times. Young fruit trees are often severely injured by defoliation, or even by having the tender bark and twigs eaten to such an ex-

tent as to cause death of the trees. The attacks and damage to young orchards generally follow a shortage of other foods.

THE MORE DESTRUCTIVE SPECIES

There are many kinds of grasshoppers which are injurious to our agricultural crops. The more important ones are: The lesser migratory locusts (*Melanoplus atl. nis* Riley), the two-striped locust (*Melanoplus bivittatus* Say), the differential locusts (*Melanoplus differentialis* Thom.), and the red-legged locust (*Melanoplus femur-rubrum* De G.).

There are other species involved, but they appear rather scattering, are of minor importance, and generally occur in fields bordering virgin lands.

CONTROL

The control of grasshoppers may be taken up under two heads:

First, *Natural*, which includes climatic conditions, predaceous and parasitic insects, diseases, birds, etc.

Second, *Artificial*, which includes all methods employed by man, such as cultivation, spraying, poison baits, hopper dozers, etc.

The complete eradication of a swarm of locusts in any given locality is almost impossible, tho under favorable circumstances, with co-operation and organization, enough can be killed to effect a complete control of the pest. However, this must be accomplished before the hoppers develop wings. Therefore, the attention of those engaged in locust destruction should be directed against the young hoppers and eggs.

NATURAL CONTROL

Insect Enemies.—There are several kinds of parasitic and predaceous insects which aid materially in the natural control of grasshoppers. Among these is a medium-sized fly, *Sarcophaga* (sp. ?), which has been bred in abundance from both nymphs and adults. This parasite was first noted at Trinidad June 1, 1916, and after haying, numerous parasitized hoppers were noted around the stacks. From two to four parasites of the above mentioned species were bred from those collected.

Other insects of secondary importance have been noted preying upon the nymphs of grasshoppers. A large, black ground beetle, (*Calosoma obsoletum* Say) was noted, on various occasions, feeding upon young hoppers. Large robber flies (*Promachus* sp.) have been seen feeding upon young grasshoppers. Solitary wasps are also instrumental in hopper control. They sting and stupefy the young hoppers and place them in their mud nests. The wasp deposits an egg among the stupefied hoppers, and, upon hatching,

the young grub has sufficient food for its development. One of the most common of these is *Priononyx atratus*.

Birds.—Insectivorous birds play a most important part in natural control of grasshoppers. They are always present thruout our agricultural districts, and are constantly feeding upon grasshoppers and other insects. The following are pointed out by W. R. Walton* as being the most important:

"Franklin's gull, bobwhite, prairie chickens, red-tailed, red-shouldered, broad-winged and sparrow hawks; the screech and burrowing owls, yellow-billed cuckoo, road-runner, nighthawk, red-headed woodpecker, kingbird, horned lark, crow, magpie, red-winged and crow blackbirds, meadowlark, lark bunting, grasshopper and lark sparrows, butcherbird, wren and robin."

All domestic fowls will feed upon grasshoppers whenever possible. Turkeys and chickens will aid materially in controlling them. They are very effective over small areas, as they will eat a great quantity of young hoppers. However, their effectiveness must not be over-estimated, as it is almost impossible for any farmer to have a sufficient flock to patrol his entire field. The wandering habit of turkeys takes them thruout the infested areas where they are very beneficial in hopper control, but chickens are of a different nature, and their houses must be placed in the infested field and be moved at intervals, if they are to rid a given locality of this pest. Mr. Jones, of Monte Vista, placed a coop and about 60 chickens (Fig. 1) in his field and affected a com-



Fig. 1.—Chickens in the field used as a method of control for grasshoppers, 1916, San Luis Valley. They did very efficient work immediately around the portable coop, which was moved every other day (Original).

*"Grasshopper Control in Relation to Cereal and Forage Crops," Farmers Bulletin No. 747, U. S. D. A. (1916), p. 12.

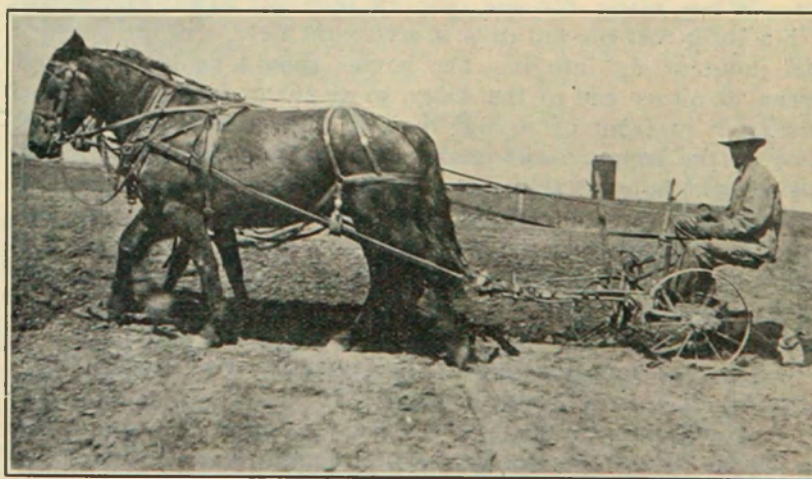
plete control immediately surrounding the house. It must be taken into consideration that it would require an enormous number of hens and considerable attention to affect control over any great area of land.

ARTIFICIAL CONTROL

In the artificial control of grasshoppers, we may consider the two main heads: *Prevention* and *Remedies*.

Under the first, attention must be given to prevent hatching and lessen egg deposition. The latter may be brot about by clean cultivation along ditch banks and fence rows. This will expose the hoppers to natural enemies and weather conditions, which will reduce their numbers and cause the remainder to oviposit in areas likely to be cultivated, and so result in a subsequent destruction of the eggs.

Exposure of the eggs to air, sunshine, natural enemies and weather conditions is very effective in hopper control. This may be accomplished by plowing, discing or harrowing. The operation should be performed before the eggs hatch. It is therefore an excellent plan, in late fall or early spring, to plow all ditch banks, fence rows, and road-sides where grasshopper eggs are known to be deposited. Plowing should be at least eight inches deep. This will bury the eggs sufficiently to prohibit most of the young hoppers from making an exit thru the soil surface upon hatching. In alfalfa fields and other places that cannot be plowed,



Breaking fallow land to destroy grasshopper eggs, San Luis Valley, 1916. (Original).

harrowing or discing will give excellent results in egg destruction. This should be to a depth of at least two inches, the ground thoroly stirred, and the egg clusters broken and exposed. This allows birds and other enemies, as well as temperature, to destroy them.

Young orchards may be protected by thoroly spraying the trees with arsenate of lead at the rate of 3 pounds of powder or 6 pounds of paste, to 50 gallons of water.

APPARATUS FOR CAPTURING GRASSHOPPERS

There are three principal mechanical devices used in catching young grasshoppers. These are all under the same general plan, but may be classed as the "Hopper Dozer", the "Balloon Hopper Catcher", and the "Live-Hopper Machine". The first two are designed to be used on level cultivated fields or meadows, and are the most economical methods for mechanically destroying grasshoppers, but their use will not insure as complete and effective control as the poison bait method. However, some users of the above machines are very much in favor of them. This is probably due to the fact that with these they can see the immediate fruits of their labor.

Hopper Dozer.—A very cheap and practical hopper dozer (Plate 1, Figs. 3-4) consists of a sheet-iron pan three or four inches deep, placed upon wooden runners with an upright oil-cloth or piece of canvas two and one-half feet high at the back. This is to prevent the insects from flying or jumping over the pan. When ready for use, put an inch of water in the pan with a little coal oil and drag it across the field, and the hoppers will jump or fly into it. The horses should be hitched, well spread, at either end of the dozer, so as not to frighten the hoppers from in front of it, and then, as the machine approaches, many of the hoppers will jump and alight in the oil and water. The winged hoppers will, in most cases, fly against the back of the hopper dozer and fall into the pan and be killed by the oil. Those that crawl out will soon die from the effects of the oil. Where the hoppers are very numerous, they will soon fill the pan and have to be removed. At intervals, a fresh supply of oil and water will be needed. To prevent slopping from end to end, it is well to put partitions across the pan every two or three feet with a small opening beneath them.

Anyone can build one of these pans or dozers to suit himself. Mr. P. K. Blinn*, of Rocky Ford, Colorado, has constructed a

*"A Hopper Dozer," Bulletin No. 112, Colorado Agricultural Experiment Station.

very inexpensive and convenient hopper dozer (Plate I, Figs. 3 and 4), which may be operated with one horse. The plan is such that any farmer should be able to construct it for himself.

The pan was made by nailing a sheet of 24-gage galvanized roofing iron, 30x96 inches, to a frame, 24x96 inches, made of two-by-fours. Three inches were allowed to turn up on either side of the frame to make the pan more secure. A strip of candle wicking was nailed beneath the iron between two rows of nails, to prevent leakage. The ends of the pan were bolted to runners made of 2 inch x 10 inch strips, 4 feet long, and at either end of this runner was a small cast iron 10-inch wheel. The object of the wheel was to steady the pan over rough places and to lighten the draft of the dozer. The pan was supported on runners about four inches above the ground and the wheels supported the runners about half an inch. A light frame, 3 feet high, covered with oil-cloth, was fitted to the back of the dozer with the smooth side in front. The bottom of the cloth was tacked to the inside of the pan, and the framework was braced in front of the runner.

The material and cost of building the dozer, according to Mr. Blinn, was as follows:

One sheet of No. 24 galvanized iron, 23 lbs., 92.....	\$2.07
One piece of 2x4, 16 ft.	
One piece of 2x4, 8 ft.	
One piece of 2x10, 8 ft.	
One piece of 1x4, 16 ft.	
Total—32 ft. at 2½c.....	.95
Three yards of table oilcloth at 18c.....	.54
Four cast wheels .....	.50
Bolts, nails and rope.....	.40
One ball of candle wicking.....	.10
Total cost.....	\$4.56

By hitching a horse in front to one runner, and having a rope from the other runner attached to the hame staple of the harness, the dozer, by the aid of the wheels, may be dragged at right angles and to one side of the horse, thus preventing the hoppers from being frightened away from the advancing pan.

Balloon Catcher.—The “balloon” hopper catcher consists of a light frame of wood twelve feet long and two feet high, to which is attached a bag about eight feet long, the framework forming the mouth of the bag. The apex is open, but, when in use, tied with a string. The apparatus is drawn by a single rope which forks and re-forks, sending a branch to each corner. The draw rope is fastened to the single-tree of a light harness or to the pommel of a saddle. In dragging this sack over the infested areas



A hopper dozer in action. One of the many machines that was used in the grasshopper campaign, 1916, San Luis Valley. Note the hoppers in the pan. (Original).

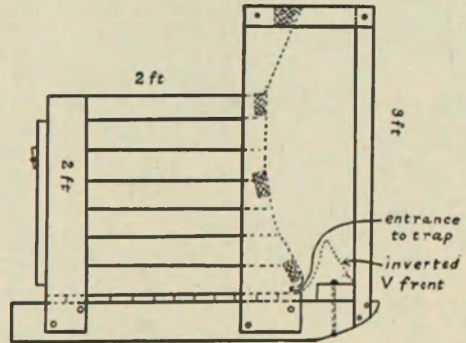
the hoppers jump to avoid it and are caught in the sack. When a sufficient quantity of hoppers are thus trapped, the rider, with the assistance of a helper, opens the apex and shakes the captured grasshoppers into a sack.

This apparatus originated in British Guiana, and is used extensively in India and other countries where grasshoppers appear in immense swarms.* It was also used effectively in Utah in the outbreak of grasshoppers in 1915, when it was reported that at least four hundred tons of grasshoppers were captured by the use of these balloons.**

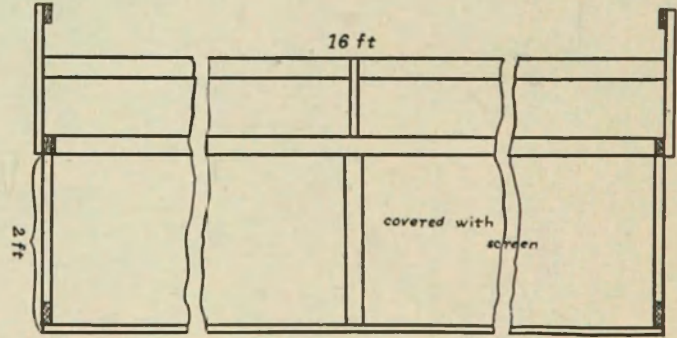
The Live Hopper Machine.—This apparatus (Plate II) was constructed and successfully used in Colorado in 1902, and has later given satisfaction as a hopper machine in Utah and New Mexico, and in the San Luis Valley the past season. It has the advantage over other hopper dozers in that it can be operated on rough areas. Its construction is very simple. It consists of a rectangular box two feet square and sixteen feet long, fastened on runners. The top and back of the box should be covered with screen wire and provided with a door for getting the hoppers out. The front should be concave, three feet high, and covered with

*Philippine Agricultural Review III, 4, 1910, pp. 237-238.

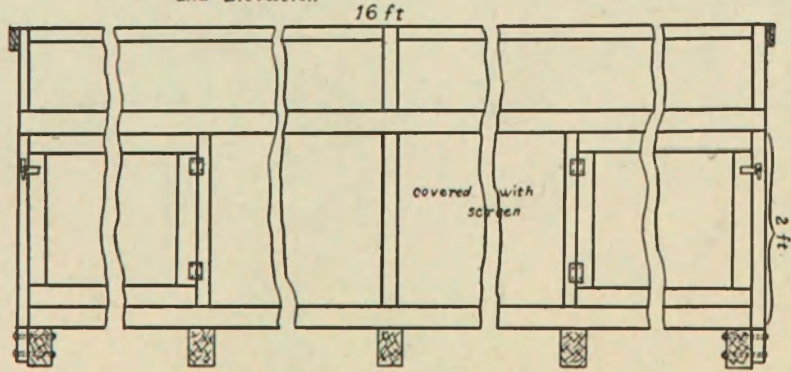
**"How to Control Grasshoppers," Utah Agr. Exp. Sta. Bul. No. 138, 1915, pp. 98.-99.



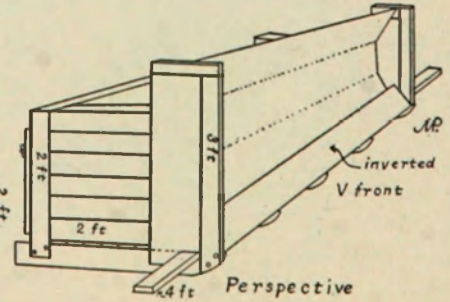
End Elevation



Top Elevation



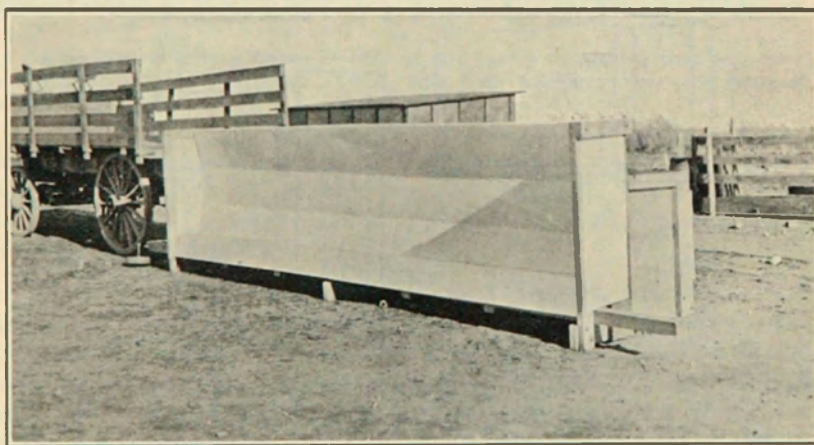
Rear Elevation



Perspective

oilcloth or tin extending to within two inches of the bottom of the machine, the floor of which is extended forward about four inches in front of the shield. A two-by-four extends outward from either end to the distance of four feet and to this is attached the single-tree. An inverted V-shaped tin is fastened to the front end of the extended floor, the back part of the V being free and slightly curved upward and extending under the base of the shield. In operation, this tin shakes up and down, and the hoppers jumping up strike the curved shield, slide down to the inverted V front, and, being unable to obtain a foothold, pass down and under the main shield and into the box.

This machine operates in the same manner as the hopper dozer, with the exception that the hoppers must be killed before the machine is unloaded. This may easily be accomplished by spraying them with kerosene.



The "Live Hopper Machine," showing concave shield front and inverted "V" at the base. These machines were used on rough areas in the grasshopper campaign, 1916, San Luis Valley. (Original).

INSECTICIDES

Insecticides used in hopper control may be grouped under two heads, those which kill by contact, such as kerosene, kerosene emulsion, etc., and those which act upon the digestive tract. The latter may be applied by means of spraying the poison directly upon the foliage which the hoppers will feed upon, or by mixing it with bran or other material in the form of a mash.

Poisonous Sprays.—Poisoning vegetation with arsenical sprays is often practical in areas where the young hoppers are

abundant and localized about the borders of the fields or elsewhere. The poisons used should be Paris green or arsenate of lead, the former at the rate of 2 pounds, and the latter at about 3 pounds of powder or 6 pounds of paste, to 50 gallons of water. Care should be taken not to use these sprays on plants where domestic animals are likely to feed. Either of the above sprays can be used very effectively after cutting alfalfa. In these cases, narrow swaths of alfalfa should be left standing at intervals thruout the field and thoroly sprayed with one of the above poisons. This green strip will act as a trap row and innumerable hoppers will be killed. After the hoppers are all killed, this trap-strip should be cut and burned, to eliminate the danger of feeding to domestic animals.

There is one objection to the use of the spray method, and that is that it is rather hard to make the spray material adhere and spread on plants sprayed. This, however, can be partly overcome by adding about 3 pounds of common laundry soap to 100 gallons of the spray.

Arsenic-bran Mash.—This can be used effectively, and it is one of the very best methods for controlling a grasshopper plague. Mix thoroly, 25 pounds of bran with 1 pound of white arsenic or Paris green, and enough water to moisten it so that the mixture will adhere. About 3 gallons of water will be sufficient. Add 2 quarts of some common cheap syrup to keep the bran from drying out too readily and make it more attractive to the hoppers.

The above quantity of materials, properly strewn, is sufficient to sow around 5 or 6 acres and will completely cover 3 acres. This would cost about 30 cents per acre, figuring the cost of materials as they were the past season.

The poison should be sown broadcast where the hoppers are the most abundant. Avoid dropping it in piles, as more hoppers are reached and better results are obtained where the particles are as small as possible. This mixture should be used with care where domestic fowls are apt to feed, as there is danger of poisoning them. However, Dr. Morrill* reports that chickens will not eat this poison mash and that there is no danger to poultry when it is scattered broadcast. His report is as follows:

“Experimentation has shown that there is no danger to poultry from eating the bran mash if it is scattered broadcast. The writer has seen no dead wild birds over ground that was treated. One season a pan of the prepared bran mash was exposed where chickens could get it if they

*“Grasshopper Control,” N. Mex. College of Agriculture and Exp. Sta. Bul. No. 102, 1916, pp. 29-30.

wished. Only occasionally would one peck at the bran and then only desultorily. None showed any signs of poisoning.

"Reports have come to the writer of chickens dying from eating grasshoppers, both alive and poisoned. Such deaths were evidently due to over-eating of a food to which the fowls were not accustomed."

Experiments were conducted the past season in Rio Grande County relative to the liability of poisoning pigs and cattle, and no ill resulted. *Figs. 2 and 3.) These experiments consisted in letting pigs and cattle graze on areas over which bran mash had



Fig. 2.—Part of a dairy herd in the San Luis Valley, where experiments were conducted relative to the liability of poisoning domestic animals by use of Paris green-bran mash, when properly applied in grasshopper control, 1916. (Original).

been strewn. In one case, 135 hogs grazed on 15 acres of poisoned alfalfa. On the third day, one pig died, but the post mortem examination showed no signs of poisoning. However, some stock died from poisoning, but upon investigation it was found, in all cases, that the poisoning occurred thru carelessness. One case, for instance, was where two calves died from licking a tub in which the poison mash had been mixed. This tub was left in the yard where the calves were running. Had it been cleaned, or turned upside down, the poisoning would not have occurred.

The following Kansas formula for poisoned bran mash for grasshoppers, developed by Professor M. F. Dean, is highly recommended by all who have used it, and gave decided results the



Fig. 3.—Part of the 553 hogs grazing on alfalfa after Paris green bran mash had been sown to control grasshoppers at the rate of eight pounds per acre. No animals were poisoned. (Original).

past season in the grasshopper control in the San Luis Valley and elsewhere:

Paris Green	3 pounds
Bran	50 pounds
Syrup (a cheap grade).....	1 gallon
Water	5 gallons
Lemons	10

Mix thoroughly the bran and Paris green while dry; dissolve the syrup in the water; squeeze the lemons into this, and finely chop the peel and pulp and add them also; pour this mixture into the bran and Paris green and stir so as to dampen the mash thoroughly. Then sow broadcast as thinly as possible. The above amount will cover, if properly applied, 6 acres of ground.

This Kansas formula has been used and checked with four other formulas: Bran, Paris green and water; bran, Paris green, syrup and water; bran, Paris green, syrup, lemon extract and water, and bran, Paris green, salt and water, and the results were decidedly in favor of the Kansas formula.

DISEASES

Grasshoppers, like other animals, are susceptible to diseases. There are two or three known to attack them:

First.—A fungous disease (*Empusa grylli* Fres.) (Figs. 5 and 6), which has been reported to be successful in grasshopper control, but later experiments have proved it to be of no practical value. It appears that under favorable conditions this disease will appear, with more or less virulence, and spread with

sufficient rapidity to cause the destruction of a large number of locusts.



Fig. 5.—Grasshoppers killed by the grasshopper disease, *Empusa grylli* Fres. Note how they cling in clusters at the top of the dead grass.

Several years ago the so-called "South African grasshopper fungus" was distributed to a large number of farmers in the State for trial against grasshoppers, and several very favorable reports were received, but the attempts at this Station to inoculate grasshoppers and spread the disease were an utter failure, both in the breeding-cage where the conditions of heat and moisture could be controlled, and in the fields. In no instance was any substantial evidence found that a single hopper had been killed by the fungus. It was decided that in every case reported, the hoppers were killed by the disease *Empusa grylli*, first mentioned above, or by parasites, and not at all by the fungus that was distributed.

A very striking peculiarity of *Empusa grylli* Fres. is, that it causes the hoppers to climb to the tops of the stems of alfalfa,



Fig. 6.—Grasshoppers killed by *Empusa grylli* Fres clinging to oat heads, Trinidad, 1916. (Original).

sweet clover, or other plants, where their dead bodies remain for days and weeks. (See Figs. 5 and 6.)

Professor Sacket*, bacteriologist of this Station, makes the following statement relative to *Empusa grylli* Fres.:

"Experiments carried on in co-operation with the Division of Entomology have demonstrated that the grasshopper is not susceptible to the organism when brought in contact with the ordinary form of the fungus, such as is obtained from the bodies of dead grasshoppers. In these experiments to which I refer, the grasshoppers were literally fed with the fungus, and the pure culture was spread upon their bodies. More than this, grasshoppers free from the disease were placed in breeding-cages with sick grasshoppers and grasshoppers dead of the disease, but, in spite of these numerous attempts to infect them, all remained healthy."

*Twenty-fourth Annual Report, Colorado Agricultural Experiment Station, p. 20.

Second— A bacterial disease (*Coccobacillus acridiorum* D'H.) was reported by D'Herelle as having worked successfully in Argentina. Later experiments with this organism, both in the Philippine Islands* and in South Africa, have proved it useless after the infection of grasshoppers in the field.

Under artificial conditions, such as are found in a laboratory, these diseases may possibly be applied with good results, but as yet, no disease organism has been found that can be artificially applied with success for the destruction of grasshoppers in the field.

WORK OF 1916

During the past season, the losses caused by grasshoppers in Colorado were particularly large. Word was received from various parts of the State reporting outbreaks and requesting information relative to their control. The prevailing condition that favored this increase of hoppers is not exactly known, but in every locality where grasshoppers occur this same increase may be looked for in any season favorable to insect development.

The value and necessity of organization and co-operation to control these serious outbreaks of grasshoppers was early recognized in the southern part of the State, the first request coming from County Agent C. E. Smith, of Trinidad, Las Animas County, June 1. On June 10th, a like request was received from County Agent E. H. Thomas, of the San Luis Valley. Later, these were followed by County Agents W. H. Lauck and G. C. Burckhalter of El Paso and Morgan Counties, respectively, and others.

In Las Animas County and the San Luis Valley, the prevailing opinion for a time was that the remedial measures recommended by the county agents, such as sprays and poisoned baits were not effective. This was due to the fact that all the grasshoppers in a given locality were not immediately killed and those that were poisoned had crawled out of sight in secluded patches of grass or under rubbish and died.

An inspection of the farms about Trinidad and the adjacent communities revealed the fact that the grasshoppers were appearing in alarming numbers. At the evening meetings held at various places to discuss the situation it was ascertained that the county had had no previous outbreaks that would necessitate remedial measures. While the people were very enthusiastic, they seemed slightly skeptical as to the control of this pest. The demonstrations held at various parts of the county were always at-

*"A Test of the *Coccobacillus acridiorum* D'Herelle on Locusts in the Philippines," Philippine Journal of Sci., X, No. 2, Sec. B. Tropical Medicine, March, 1915, pp. 163-176.

tended by a good representation of the community, but the results obtained were not as satisfactory to the minds of the farmers as they should have been. This was due to the fact that the grasshoppers were, in every case, just hatching, thus furnishing a fresh supply over a period of time longer than the effectiveness of the poison. The hoppers being very small, from newly hatched to not over one-half grown, when killed, soon dried and were blown away, rendering it almost impossible to find any dead ones, and with the increasing supply of newly hatched ones it appeared as though the remedy was of no avail.

It was ascertained that Mr. C. E. Smith had made an application of the Kansas formula for bran mash on a small garden tract near Trinidad when the hoppers were over one-half grown. Here the results were clearly in evidence. Previous to the application, the hoppers were in a bean and cabbage garden in alarming numbers. Investigation showed these fields free of hoppers. In the adjacent, uncultivated, weedy areas they were plentiful, but up to the line of poison, or where the bran mash had been spread, they disappeared entirely.

Through the efforts of County Agent E. H. Thomas of the San Luis Valley, it was found that several methods of grasshopper control were in progress, such as sprays, poison bait and the hopper dozer.

The condition of hatching was about the same as in Trinidad, but the hoppers were slightly larger, and the same general opinion as to the effectiveness of poisons prevailed. However, the poisons were doing their work, but the hoppers dying in secluded places made it appear otherwise.

At the "West Side Farm", Mr. McArthur had sprayed a fifteen-acre tract of alfalfa with Paris green and reported his results as negative. Upon a close inspection it was found that the spraying had been very effective. On making various examinations thruout the field, it was ascertained that there were, on an average, 25 dead grasshoppers for each square foot of area. Figuring from the size of the hoppers in question, this gave a total of 5 bushels of dead hoppers per acre. Mr. McArthur had previously stated that, in a previous inspection made by him, he found only three dead hoppers. This was due to the fact that he did not know where to look for them. However, he admitted that the number of live hoppers had decreased materially, but it was his opinion that they had migrated to an adjacent field. The apparatus used in this experiment was an ordinary barrel spray with a series of 13 nozzles attached. (Fig. 7.)

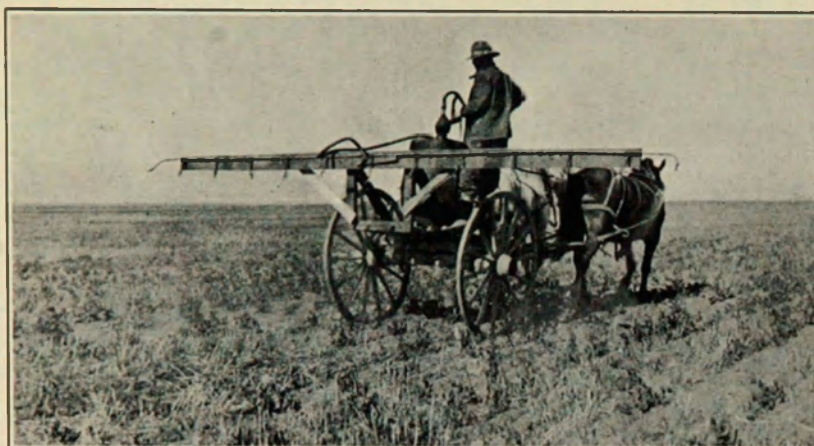


Fig. 7.—A 18-nozzle beet spraying machine. The type that was used in the grasshopper campaign, 1916, San Luis Valley. (Original).

In fields where the Paris green bran mash had been applied and reported ineffective, an estimate as to the efficiency of the poison was made, and it was found that the dead hoppers averaged 37 to the square foot. On computation, it was found that, at this rate, there would be about 9 bushels of dead hoppers per acre.

The general prevailing opinion at that time was that the hopper dozer was more effective than the poison. This was undoubtedly due to the fact that the fruits of their labor were discernible and not scattered, as was the case with the poison. However, estimates showed that the spray and the poison bait were at least four times as effective as the hopper dozer.

Demonstrations relative to mixing and applying sprays and poisons in various communities were held, and always with a good attendance of interested farmers. Several trips were made to fields of peas, part of which had been plowed in the early spring, and the remainder left uncultivated, the peas being simply drilled into the old stubble as is the common custom in that vicinity.

The plowed areas demonstrated quite clearly the effect of early spring or fall cultivation for the destruction of eggs, as there were very few, or in most cases, no grasshoppers in the cultivated plots, while where the peas were simply drilled in the stubble, there appeared about as many hoppers as in the uncultivated fields of that vicinity.

An inspection of the infested areas of El Paso County revealed the fact that the same general opinion prevailed as in the San Luis Valley. However, it was found that the main trouble was in the mixing and application of the poison. The mixtures examined were poorly made, the syrup having been poured directly into the bran and Paris green, consequently causing it to be formed into small balls, so that it could not be applied properly. The applications were made from a tub of this mixture placed in the back of a buggy and driven promiscuously thru the fields.

Too much stress cannot be laid upon mixing and applying the poison, as the success of the application depends entirely upon these operations. If the points relative to mixing and applying, heretofore discussed, are carried out in detail, I believe there need be no trouble in controlling a plague of hoppers or from poisoning animals.



Shed in which was mixed by hand a large quantity of Paris green-bran mash during the grasshopper campaign, 1916, San Luis Valley (Original).

The conditions in Pueblo County were somewhat different than in the other infested territory, they having had a slight outbreak of hoppers two years previous and being informed as to remedial measures. The outbreak was not very alarming, but in most places where hoppers occurred, the bran mash had been applied with good results.

The campaign was taken up by County Agent Stanley V. Smith, thru the county commissioners, who furnished a given amount of Paris green to those who would apply it. This Paris green was distributed from various centers, consequently it had a wide distribution and was applied in many localities, but not in all cases where it should have been.

One field on Orchard Mesa was very badly infested, there being 7 acres of alfalfa which was almost entirely defoliated. The owner was distributing Paris green for the county and did not deem it necessary to apply it to his own land. Adjacent to this infested field were 15 acres of beans. The idea of the owner was to let the hoppers eat his alfalfa in order to save the beans. Had he applied the Paris green bran mash, he could have saved the entire crop. The yield would have been at least five tons, and hay was then selling at \$13.00 per ton. This individual was paying a toll of at least \$65.00 to the hoppers and not killing one, where he could have made an entire clean-up for \$5.00, had he applied the bran mash.

At the time of visiting the above place, the hoppers were leaving the defoliated alfalfa field and entering the bean patch around the edges. In all probability the entire bean crop was destroyed by the grasshoppers.

In accordance with the pest law, several pest districts were formed thruout the State, three in the San Luis Valley, two in Rio Grande, one in Saguache County, one in the Fountain and Mesa district in El Paso County, and three were arranged for in Logan County, giving in the latter an almost continuous district thru the Platte Valley from Messex to Red Lion. This covers the principal irrigated section of said county.

On July 1, a second trip was made to the San Luis Valley at the request of the commissioners of Rio Grande County, to further the work commenced in the grasshopper investigations and assist Mr. W. E. Kistler, who was to be the pest inspector for the above mentioned districts.

The first duty of the inspector was to check over various previously poisoned places to determine the effectiveness of the Paris green bran mash. The first forenoon, four farms were visited where there had been from 70 to 105 acres each, poisoned three weeks previous. The results were surprisingly good. In three out of the four farms visited, a complete eradication, instead of a control, had been effected. This was especially true on Mr. Tiner's premises. Mr. Tiner was the first man in that section to take hold of the poison bait method for grasshopper control, and

it was upon his farm that the first demonstrations were conducted. At that time the hoppers were so numerous that a complete devastation of his crop was threatened. On checking over the results, three weeks later, one had to go, on an average, from 30 to 60 steps before seeing a live grasshopper.

In a great many places in the valley, numerous pigs are raised and pastured on alfalfa, and in most cases these fields were badly infested with grasshoppers. The owners of such fields were skeptical about treating these fields for fear of poisoning their stock. While some were not afraid of the Paris green directly, they were afraid that the hogs would eat the dead hoppers and thus be poisoned. However, this point was cleared by Tiner, Drake, Arthur and Davis. Mr. Tiner had 28 spring pigs (Figs. 2 and 3) feeding at all times on the poisoned area, and the other men had 135, 243, and 175 pigs, respectively, of all ages, feeding upon grasshopper-infested pastures that had been sown with Paris green bran mash, and one pig died. The owner thought this pig was poisoned, but it is possible that one pig out of 553 could have died from some other cause than poisoning from the bran mash.

In the counties of Rio Grande and Saguache, San Luis Valley, practically all the infested land, where control work was conducted, was organized into pest districts and the farmers used the Paris green bran mash according to the Kansas formula. All materials used were purchased in large quantities and distributed from a central point, ready mixed.

In Rio Grande County, Mr. Fuller, a druggist of Monte Vista, furnished most of the poison used. This he mixed, upon application, and furnished to the farmers at a less rate than they could buy the materials at retail and do the mixing themselves. During the campaign he mixed and distributed:

6,550 pounds of Paris green
38 tons of bran
41 cases of lemons
1,380 gallons of syrup

However, this does not represent all the materials used in the two pest districts in his county, as a large quantity of Paris green was obtained from the sugar factory and some from Center.

In Saguache County, Mr. Sumpter, a druggist, furnished and mixed the materials used. An exact account of the amounts used was not kept, but it is safe to estimate that the quantity used was at least half that of Rio Grande County. A machine mixer, (Fig. 8) was used by Mr. Sumpter which greatly lessened the work of

mixing the poison. It consisted of a cylinder sufficiently large to hold at least 400 pounds of bran, revolving upon an axle, the power furnished by an old Ford machine. Only 100 pounds, dry weight, was mixed at a time. This gave plenty of room for mixing. The time required to mix and sack one filling was eight minutes.

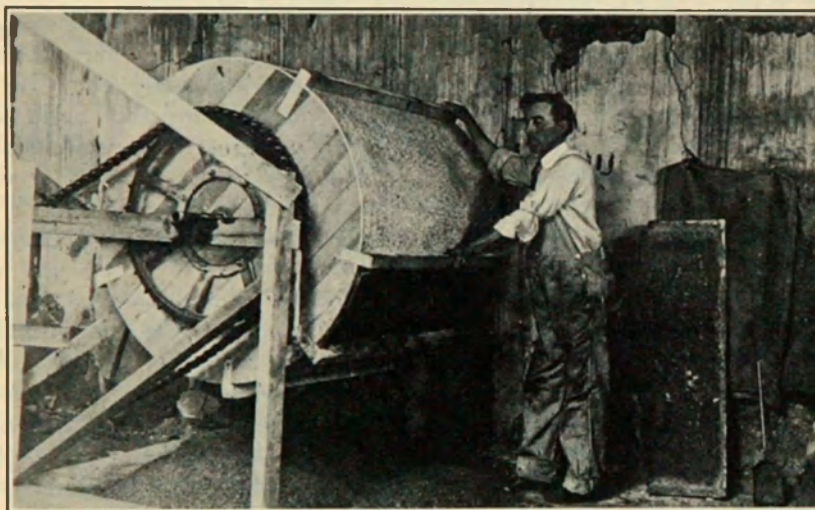


Fig. 8.—Sumpter mixing machine used to mix Paris green-bran mash, Center, Colorado, 1916. Time required to prepare, mix and sack 100 lbs., dry weight, of the bran mash, eight minutes. (Original).

In the San Luis Valley and elsewhere where the Kansas formula for poisoned bait was used, the results obtained, as a whole, were entirely satisfactory, the County Agent, E. H. Thomas, reporting a gain of from \$3 to \$5 per acre on something over twenty thousand acres in favor of the treated areas. In many cases a complete eradication, instead of control, was effected. The results are shown in the table on pages 28 and 29, which is compiled from information obtained thru a circular letter.

The question of grasshopper control is a very important one in any district where grasshoppers occur in sufficient numbers to warrant remedial measures. It is hoped that the results of our experimental and field demonstration work will convince the most skeptical person that the destruction of this pest in future outbreaks will be a very simple matter.

Farmers living in districts where grasshoppers are destructive or threaten destruction to crops, should organize at an early

date and order a sufficient quantity of necessary materials for distribution when necessity demands. The mixture should be applied in the evening, or in the early morning before the hoppers begin to feed. In fields where the hoppers are localized, the poison should be scattered over the infested areas. In fields where a total infestation occurs, it should be applied everywhere and at the rate of about 8 pounds to the acre.

THE FOLLOWING TABLE IS A SUMMARY OF THE INFORMATION OBTAINED IN AUGUST, 1916, RELATIVE TO THE RESULTS OF THE GRASSHOPPER CAMPAIGN IN THE SAN LUIS VALLEY, COLORADO.

The information in this table was supplied by the farmers whose names appear therein and the statements in the column headed "Remarks" were taken from their communications.

REPORTED BY	ACREAGE		Stock Poisoned	Grass-Hoppers Appeared	Land Plowed	REMEDIAL MEASURES		Results	REMARKS
	Cultivated	Treated				What Used	Time Applied		
J. McLodgan	160	160	None	June	Spring & Fall	Bran Mash	July	Good	Only a few hoppers left.
Alice B. Cheney....	925	925	None	....	Spring & Fall	Bran Mash	July	Splendid	
Anna McCormick ..	155	100	None	May	.....	Bran Mash	June	Good	Ravages effectively stopped. Killed cutworms also.
F. S. Jones.....	144	115	None	May	Spring & Fall	Bran Mash	May	98% perfect	Used dozer on pasture. Partial success.
Henry Seth	155	120	None	June	Spring only	Bran Mash	June	Killed them all	
A. J. Stoeber.....	249	100	None	April	Spring only	Bran Mash	May	Good	Poisoned pasture; lost no stock.
A. O. Miner.....	170	120	None	May	Spring & Fall	Bran Mash	June	Fine	Results entirely satisfactory
V. Drake	310	250	1 pig	May	Spring only	Bran Mash	June	Good	Poisoned pasture, grazing 135 head hogs; lost one.
I. P. Taylor.....	160	103	None	May	Early Fall	Bran Mash	June 15	Pest practically destroyed	Very favorable.
C. W. Myers.....	500	500	None	May	Spring & Fall	Bran Mash	June	Favorable	Bran mash a good remedy.
J. M. Arthur.....	1975	1975	None	April	Spring	Bran Mash	June & July	90% killed	Poisoned pasture. Lost no stock. Have 243 head.
F. H. Johnson.....	150	130	None	April	Spring	Bran Mash	June & July	75% killed	Results very satisfactory.
W. H. Towne.....	...	160	None	June 1	Spring	Bran Mash	June	Good	Dozer used, but abandoned it for poison.
Fred Schield	157	17	None	July	Summer 1915	Bran Mash	June	Favorable	
C. F. James.....	380	6	None	June	Spring & Fall	Bran Mash	....	Good	

G. W. Maxey.....	128	60	None	June	Spring & Fall	Bran Mash	....	Fair	Lost a few chickens.
E. C. Harper.....	116	80	None	May 15	Spring & Fall	Bran Mash	....	Very good	
E. G. Mathias.....	160	150	None	....	Spring & Fall	Bran Mash	....	Good	Sawdust used with fair results
W. E. Kistler.....	290	100	None	June	Spring	Bran Mash	July	Good	Used 200 lb. sawdust mixture; results good.
Cris Selters	503	100	None	June	Spring	Bran Mash	June	Fair	Results fair.
Felix Kaiser	145	30	None	June	Spring	Bran Mash	July 7	Very good	Plowing destroys many eggs.
James H. Neeley....	148	113	None	May	Spring	Bran Mash	....	Very satisfactory	Used spray, 2 lbs. Paris green to 1 bbl. water; results poor.
M. Metz	395	130	None	May	Spring	Bran Mash	June	Very good	Poisoned mash, best control. Not many left.
W. L. Starbuck....	450	60	1 calf*	May	Spring & Fall	Bran Mash	June	Very good	Got to mixing pan and licked it.
W. A. Elwood.....	110	30	None	July 1	Fall & Spring	Bran Mash	July	Good	No hoppers on fall plowed land.
C. G. Wright.....	296	150	None	May	Fall & Spring	Bran Mash	June	Very favorable	Land fall plowed had scarcely any hoppers.
J. W. Davis.....	368	368	None	May	Fall & Spring	Bran Mash	June	Good	175 hogs on poisoned pasture. Lost none.
O. A. Cramer.....	335	175	None	April	Fall & Spring	Bran Mash	July	Good	Used with good success elsewhere.
Seth Methias	440	440	None	April	Spring	Bran Mash	....	Very favorable	Used dozer; results good.
H. M. Wright.....	155	140	None	June	Spring	Bran Mash	June & July	Very good	
J. Becraft	260	40	None	May 15	Spring	Bran Mash	June	Extra good	Results very favorable.
E. W. Jackson.....	110	110	None	April	Spring	Bran Mash	May	Very favorable	Used 700 lb. poison, poisoned pasture; lost none of 78 head.
W. W. Wright.....	605	100	None	May	Fall & Spring	Bran Mash	....	Good	
Center	160	160	None	....	Fall & Spring	Bran Mash	....	Good	75 hogs on poisoned alfalfa; Lost none.
J. P. Warren.....	130	50	None	May	Spring	Bran Mash	June	Very good	
R. C. Dillon.....	155	20	None	....	Spring	Bran Mash	....	Very favorable	Used 200 lbs. on 20 acres.
B. E. Newmeyer....	205	150	None	May	Fall & Spring	Bran Mash	June & July	Good	Results very favorable.
B. H. Smith.....	150	140	None	June	Fall & Spring	Bran Mash	June	Cleaned up	