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GRASSHOPPER-BAIT TESTS IN COLORADO

By F. T. COWAN

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GRASSHOPPER-BAIT TESTS IN COLORADO

By F. T. COWAN*

The work reported in this paper was undertaken to determine the most economical and efficient grasshopper bait for Colorado. In making this determination, a field-plot method, together with statistical analysis of the data, was used.

Review of Literature

The history of the development of present-day methods for grasshopper control is varied and interesting. Riley (18) reported experiments with poisoned baits as early as 1877. These baits consisted of paris green and flour mixed at the rate of 1 to 30. Experiments were conducted with both dry and wet mixtures. Riley did not personally conduct these tests, altho they were done under his supervision. One man in Minnesota, reported approximately 50 percent reduction of the hoppers in an enclosed plot a rod square. He scattered the dry bait early in the morning while the grass was wet with dew. Other workers did not report such encouraging results and Riley summed up the experiments as being of little value.

Bran, arsenic and sugar were first used in combination in 1885 by Coquillett in California. This work was reported by Riley in 1891 (19). Coquillett used a mixture consisting of bran 6 parts, arsenic 1 part, sugar 1 part and enough water to make into a wet mash. This mixture was placed in small piles in vineyards and orchards. Coquillett insisted very emphatically that the sugar was added solely to cause the arsenic to adhere to the bran. He made crude tests to substantiate his belief. It was also stated that molasses was used in California by individual growers in place of the sugar. Good results were reported from the use of this bait.

Little or no experimental work was done for a number of years following Coquillett's recommendation. Howard (12) in a letter to a plantation manager in Mississippi, under date of July 11, 1899, did not advise the use of poisoned-bran mash on large scale operations. In the same publication Howard cited a note from a farmer in Texas who had secured good results by broadcasting a bait consisting of bran 10 pounds, sorghum molasses 1½ gallons, arsenic 1 pound.

The next important step in the development of grasshopper baits came when Norman Criddle of Manitoba first used his famous ''Crid-

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dle Mixture.'' According to Gibson (8) this was accomplished in 1901. The bait consisted of fresh horse manure, salt and paris green. This was probably the first instance where salt was used in the bait.

''Criddle Mixture'' was used extensively for a number of years in different parts of Canada and the United States. The formula varied almost as widely as the users thereof. Results were also quite variable. Hunter (13) reported Criddle Mixture as unsatisfactory in California in 1904. Fletcher (3) reported good results in Canada in the same year. Criddle Mixture was advised in Kansas in 1905, by Geisman (7) in Michigan in 1910, and by Washburn (21) in Minnesota in 1911. Headlee reported it as unsatisfactory in Kansas in 1912.

During the time that ''Criddle Mixture'' was being used so extensively some workers were advising the use of bran, arsenic or paris green and molasses. This formula was also varied to suit the whim of each investigator.

In 1911 Milliken of Kansas, started experimenting with citrus and other fruits as attrahents in grasshopper baits. The final result of this work was the ''Kansas Formula,'' reported by Dean (2), which is still being used in Kansas and other states. The bait consisted of bran 20 pounds, paris green 1 pound, syrup 2 quarts, oranges or lemons 3 fruits, water 3½ gallons. Workers in other states adopted the ''Kansas Formula'' so that it was regarded as a standard up to 1921.

During the period following 1911 much experimental work was done with grasshopper baits. Hunter and Classon (14) in 1913 used lemons, anise oil, stale beer and vinegar, alone and in combination with beet and cane syrup. The poisoned bran was placed on the ground in small piles. Counts were made on 3 successive days of the grasshoppers feeding on the baits. This method was probably the forerunner of the ''pan bait'' methods so widely used later.

In 1915 Webster (23) in experiments with the Kansas Formula and Criddle Mixture, advised doubling the number of fruits recommended by Milliken. Morrill (15) in extensive tests with fruits and molasses in Arizona in 1918 did not find this increase to be justified. He used a pan-bait method and supplemented this by field plots in which the percentage of kill was estimated. Morrill repeated his experiments but took a straight average with weighted results.

Gibson (9) first used sawdust in 1915 as a substitute for bran. He found that a 1 to 1 mixture with bran gave as good results as straight bran. Gibson used 4 to 5-acre plots with no replication. Results were based on an average of the counts on 10 separate square yards taken diagonally across the plot. Morrill (15) found that pure sawdust was no good but a 1 to 1 mixture gave as good results as bran. Granovsky (11) used straight sawdust on a large campaign in Wisconsin in 1925 with excellent results.

Flint (4) tested ground beans and alfalfa as attrahents to replace molasses in 1920. He claimed equally good results. Paper, treated with paris green, was also used to replace poisoned bran. Results were based on an estimated count on large plots with 1 to 6 replications. In 1920 Ford and Larrimer (5) made extensive tests with fruits and molasses. They found that "black strap" molasses gave the best results. Salt was found to be unnecessary. A pan-bait method was used, but the results were later substantiated by a field-plot method in which duplicate tests were made.

Parker and Seamans (16) tested four chemical attrahents to replace citrus fruits, in 1920. They used a pan-bait method with four replications. Amyl acetate, at the rate of 3 ounces to the 100 pounds of bran, was found to give better results than citrus fruits.

Corkins (1) firmly established liquid sodium arsenite, used at the rate of 1 quart (8-pound material) to 100 pounds of bran, as a substitute for arsenic or paris green. Dry sodium arsenite was used as early as 1911 by Washburn (22) in Criddle Mixture. Swenk (20) made a series of tests with various toxic agencies. He concluded arsenic was less efficient when combined with molasses, but that the efficiency of sodium arsenite was increased by the use of the attrahent.

Since Parker and Seamans discovered amyl acetate as a substitute for citrus fruits in 1920, there has been nothing added to the "Standard Formula." On the other hand, most workers have been doing all in their power to simplify and cheapen the bait as much as possible. Salt has been eliminated in most states, altho it is felt by many that it is valuable on acid or neutral soils. Molasses and amyl acetate have both been discussed at great length, but are still being used in most states.

At the present time Dr. J. R. Parker and R. L. Shotwell of the United States Bureau of Entomology, are carrying on extensive tests in Montana and North Dakota. The system being used for making the tests is similar to the one used in this work.

1931 EXPERIMENTS

MATERIALS.—The following baits were used in the 1931 experiments and will be referred to later by the numbers used below:

Bait 1 Bran, arsenic and water or basic formula
Bait 2 Basic formula plus cane molasses
Bait 3 Basic formula plus beet molasses
Bait 4 Basic formula plus cane molasses and amyl acetate

Bait 5 Basic formula plus beet molasses and amyl acetate
Bait 6 Basic formula plus salt
Bait 7 Basic formula plus cane molasses, amyl acetate and salt
Bait 8 Basic formula plus beet molasses, amyl acetate and salt
Bait 9 Purina sweet roughage plus arsenic, amyl acetate and water
Bait 10 Basic formula plus salt and amyl acetate
Bait 11 Dried beet pulp plus salt and amyl acetate
Bait 12 "Delicious Hopper" bait. Product of the Raven Honey Dew Mills, Omaha, Nebraska.

It will be noted from the above list that each attrahent has been taken separately and in combination with each of the others, except amyl acetate. This one was not used alone in any bait in this series of tests.

All baits except 9, 11 and 12 were mixed according to the following formula:

Bran	100 pounds
Sodium arsenite	1 quart
Molasses (when used)	2 gallons
Salt (when used)	5 pounds
Amyl acetate (when used)	3 ounces
Water	14 gallons

In all baits having bran as a base, a coarse material entirely free from shorts and middlings, was used. This type of bran absorbs a large amount of water, scatters well and does not endanger livestock and birds.

The sodium arsenite which was used in all baits, was liquid containing 8 pounds of arsenic to the gallon. It mixes readily with water and stays in solution.

Both the cane and beet molasses were of a cheap grade commonly sold for stock feed. The following analysis was supplied by the chemist of the Great Western Sugar Company factory at Fort Collins:

	Beet Percentage	Cane Percentage
Moisture	23.45	28.47
Dry substance	76.55	71.53
True sugar	42.54	29.98
Raffinose	3.85	....
Ash on original	13.25	12.64
Invert sugar	.38	20.28
Apparent sugar	52.00	50.00

Common table salt was used in all baits containing that ingredient.

The amyl acetate was of a technical grade.

Bait 9 was a material commonly sold as a stock food, but since large quantities of this product have been sold for grasshopper baits, it seemed advisable to include it with those to be tested. According to the analysis tag it contained cottonseed meal, wheat bran, ground grain screenings, molasses and 2 percent iodized salt. The material is finely ground and for this reason it is hard to mix and scatter, having a tendency to "ball up" and fall in lumps when spread in the field. Materials which do not "flake out" well in scattering are dangerous to livestock, and for this reason alone the material cannot be highly recommended for grasshopper baits.

Bait 11 contained dried beet pulp as a carrier for the poison. In price, dried beet pulp compares rather favorably with bran, since it is more bulky and can be spread over a relatively larger acreage. It is capable of absorbing almost twice as much water as coarse bran, altho it is a little harder to mix, since the water is not taken up so readily. This water-absorbing capacity may be an important item in dryland poisoning. In spreading value it compares favorably with coarse bran, since there is no tendency to "ball up." Because of the greater bulk, however, it is necessary to increase the amount of sodium arsenite by 50 percent.

Bait 12 consisted of a commercial bait manufactured by the Raven Honey Dew Mills of Omaha, Nebraska. It contained all of the necessary ingredients except the water. No formula was furnished by the makers of this bait.

METHODS.—The method used in gathering these data is a modification of the one used by Ford and Larrimer (5). It is particularly well adapted to the comparison of grasshopper baits under actual field conditions.

Description of Plots. — In this work square ¼-acre plots were used. These plots were laid out with stakes on the day preceding the placing of the baits. Where possible, alfalfa land having a succulent growth of vegetation and an abundance of hoppers, was chosen. The plots were staked out in straight rows, with a 10-foot alley on each side. The alleys were left as barriers to help prevent migration from one plot to another and were not poisoned.

Method of Gathering Data.—All baits were scattered between the hours of 6 a. m. and 7:10 a. m. Special emphasis was placed on starting operations at an air temperature of 65 degrees F. According to Parker (17) this is approximately the lowest point at which grasshoppers feed.

Sweepings were made at 3:00 p. m. on the same day. This period gave the hoppers ample opportunity to feed on the bait, but did not allow enough time for them to become logy from the effects of the poison.

An ordinary sweep net containing a cylindrical pasteboard carton, was used in collecting the hoppers. This carton had a capacity

Table I.—Example of Method Employed in Tabulating Data.—Series I

Bait	First day	Second day	Third day	Fourth day	Total dead	Total alive	Total caged	Total mechanical injury	Corrected kill	Corrected percentage kill
1	7	57	10	6	80	31	111	16	64	57.6
2	50	67	7	1	125	17	142	21	104	73.2
3	29	56	10	1	96	34	130	19	77	59.2
4	19	42	5	1	67	14	81	12	55	67.9
5	19	43	4	2	68	12	80	12	56	70.
6	9	15	2	2	28	24	52	8	20	38.4
7	29	12	2	0	43	11	54	8	35	64.8
8	33	44	6	3	86	24	110	16	70	63.6
9	8	24	8	2	42	52	94	14	28	29.7
10	19	37	5	0	61	41	102	15	46	45.
11	17	36	13	2	68	22	90	13	55	61.1
12	22	40	5	1	68	25	93	14	56	60.2
Check	1	5	7	8	21	120	141	....	....	14.8

Aug. 11, 1931. Time 6:10-7:10. Temp. 58-67.

Sunny, warmed up fast.

West Fort Collins Oil Field on Evans Place.

Hoppers plentiful. **Femur rubrum** and several species not of economic importance.

of approximately 1 quart and was screened at the bottom and top. It was placed in the net with the lid removed, and held there by a rubber band. All sweepings were made near the center of each plot in order to minimize the errors caused by migration.

When sufficient grasshoppers had been collected, the lid was replaced and the entire cylinder removed from the net. The hoppers from each plot were swept into a separate carton bearing a number corresponding to the number of the bait which had been scattered on that plot. Immediately after all plots had been swept, the cartons were brought into the laboratory and the hoppers dumped into wire screen cages. It was felt that the method reduced the possibilities of mechanical injury to the minimum.

Tabulation of Data.—The dead hoppers were removed from the cages each day, their numbers noted and recorded. On the fourth day the remaining live ones were also removed and the total number caged computed.

A control cage of unpoisoned hoppers was included in each series. The purpose of this was to determine the percentage that died from mechanical injury. This was probably unnecessary inasmuch as the data were to be used in making comparisons between individual baits. It did, however, decrease the size of the numbers and had the effect of leveling the percentage of kill in the different replicates. In order to accomplish this, the percentage of dead in the control cage was taken of the total caged from each individual plot in the series. The number obtained was then subtracted from the total dead in each cage. The corrected number dead was then divided by the total number caged, to obtain the corrected percentage dead for the treatment.

In order to illustrate this more fully a complete series from the daily notes is given.

It will be noted from Table I that the baits were scattered on the morning of Aug. 11 between the hours of 6:10 and 7:10 a. m. Sweepings were made on the same day at 3:00 p. m. The first counts of dead hoppers were made during the afternoon of Aug. 12. To illustrate further; on the first day, Aug. 12, there were 7 dead hoppers in the cage labeled Bait 1; on the second day 57, on the third 10, and on the fourth 6, or a total of 80. On the fourth or last day of the series, there were still 31 live hoppers remaining. This gave a total of 111 in the "total caged" column. In the same series 14.8 percent of the hoppers died in the control cage. Taking 14.8 percent of 111 gave a total of 16 in the "total mechanical injury" column. This number subtracted from 80 gave a total of 64 in the "corrected kill" column. The "corrected percentage kill" was then computed by dividing 64 by 111.

Table II.—Tabulated Data for the Entire 1931 Experiments.

Bait No.	1	2	3	4	5	6	7	8	9	10	11	12	Ave. of Rep.
1	57.6	73.2	59.2	67.9	70.0	38.4	64.8	63.6	29.7	45.0	61.1	60.2	57.5
2	56.2	65.9	57.1	70.7	81.0	46.6	69.8	42.1	34.7	47.9	56.6	56.1	57.0
3	40.5	55.0	55.4	60.0	63.8	51.7	75.4	79.6	36.5	62.9	29.7	57.8	55.6
4	58.2	77.6	76.1	60.5	70.6	57.3	61.8	76.1	53.4	60.8	56.4	62.3	64.2
5	42.3	55.1	54.0	52.2	49.6	58.0	56.5	60.6	36.9	61.1	51.2	53.9	52.6
6	68.9	84.3	66.9	76.0	80.4	69.3	60.9	71.7	53.3	69.2	69.6	77.1	70.6
7	73.0	68.6	66.8	48.7	67.1	36.3	50.0	55.2	39.4	42.4	48.6	53.3	54.1
8	68.6	61.2	67.3	61.3	64.0	44.4	59.1	64.7	41.3	46.0	36.4	40.1	54.5
9	67.2	68.0	68.5	60.8	70.9	65.5	55.9	64.4	49.4	59.1	55.0	66.6	62.6
10	57.0	60.6	57.3	57.3	61.5	57.8	54.3	53.7	40.0	44.2	45.9	51.6	53.4
11	69.6	76.6	75.4	74.7	72.1	73.1	65.6	72.8	47.2	61.2	56.9	62.9	67.3
12	74.2	72.5	74.1	70.1	70.0	73.3	62.7	67.8	44.4	57.7	64.1	67.7	66.5
													General mean
Average kill	61.1	68.2	64.8	63.3	68.4	55.9	61.4	64.3	42.1	54.8	52.6	59.1	59.6

RESULTS.—In Table II the corrected percentage of kill for each bait in each replicate is given. The averages of the baits for the 12 replications are tabulated at the bottom of the table. The averages for the replicates are given on the right. The general mean for the entire experiment was found to be 59.6.

Statical Analysis of the Data.—In the analysis of the data a generalized probable error was calculated for the entire experiment. The Variance Method* as given by Goulden (10)** was employed as it allows the errors due to replicates and treatments to be removed from the experiments.

Determination of Significance.—The Standard Error in itself has little value unless it can be used to determine whether or not there are some real differences in treatments. This difference was calculated in the manner suggested by Goulden (10).

$$\text{SE of difference} = \sqrt{E_a^2 + E_b^2}$$

Where E_a = SE of one treatment

E_b = SE of another treatment

$$\text{Significance of difference} = \frac{\text{Difference}}{\text{SE of Difference}}$$

In the fourth column, Diff./SE in Table III*** the figure is the ratio of the difference in kill between that bait and Bait 5, the one having the greatest average kill, divided by the Standard Error of the difference. In this way an "elimination level" has been established at a point where Diff./SE equals two, indicating odds of 22:1. This point is arbitrary, depending upon the nature of the tests and the degree of precision required by the worker. Likewise, it is possible to compare any pair of treatments in the series to determine significance.

*This is sometimes called "Student's" generalized probable error formula.

**In this work Standard Error has been used to replace Probable Error.

***In Table III all baits are compared with Bait 5.

Table III.—Average Kill and Establishing Elimination Level.

Bait No.	Percentage kill and SE	SE of Diff.	Difference	Diff./SE
5	68.4±2.41	.. ....	.... ..	.. ....
2	68.2±2.40	3.41	.2	.05
3	64.8±2.29	3.32	3.6	1.08
8	64.3±2.27	3.31	4.1	1.23
4	63.3±2.23	3.28	5.1	1.55
7	61.4±2.17	3.24	7.0	2.16
1	61.1±2.16	3.23	7.3	2.26
12	59.1±2.09	3.19	9.3	2.91
6	55.9±1.97	3.11	12.5	4.02
10	54.8±1.93	3.08	13.6	4.41
11	52.6±1.86	3.04	16.6	5.46
9	42.1±1.49	2.83	26.3	9.29

SUMMARY OF 1931 EXPERIMENTS

In Table III all baits are listed in the order of their efficiency. In this way an elimination level is established below which all baits may be regarded as inefficient. It will be noted that Bait 5 (beet molasses and amyl acetate) ranks at the top of the list, with Bait 2 (cane molasses) a close second. Of all the baits tested, these two were the only ones which showed a significance over Bait 1 (the basic formula). Baits 3, 8, 4 and 7 are better than Bait 1, but the difference is not significant.

Bait 6, containing salt alone, ranks below Bait 1. Baits 7 and 8 (both containing salt) are slightly better, but the difference is not significant. This indicates that the salt is not an attrahent under Colorado conditions.

Amyl acetate seems to be a desirable ingredient in combination with beet molasses but is apparently not necessary when cane is used. This point, however, is only indicated since there is no significance between any of the baits containing either molasses alone or in combination with amyl acetate.

The results in Table III show rather conclusively that pure bran should be used in all commercial baits in order to obtain the highest efficiency. Baits 9 and 12 gave results comparable to the amount of bran contained in their makeup. Altho dried beet pulp did not rank above the basic formula in 1931, it was felt that due to its good qualifications as a carrier it should be tested further. The formula was changed in 1932 by the elimination of the salt and the addition of beet molasses.

1932 EXPERIMENTS

In order to test further the efficiency of those baits falling above the elimination level in Table III, experiments were undertaken in 1932.

MATERIALS.—The following baits were selected for these tests:

Bait 1 Bran, sodium arsenite, water (Basic)
Bait 2 Basic plus cane molasses
Bait 3 Basic plus beet molasses
Bait 4 Basic plus cane molasses and amyl acetate
Bait 5 Basic plus beet molasses and amyl acetate
Bait 6 Basic plus amyl acetate
Bait 7 Dried beet pulp, molasses, amyl acetate, sodium arsenite and water.

All baits except 6 and 7 were tested in 1931.

METHODS.—The experiments were conducted the same as in 1931.

EXPERIMENTAL RESULTS.—In Table IV the corrected percentage of kills is given for each treatment together with the average kill for each treatment and the averages for the replicates. The general mean for the experiment was found to be 50.9.

Table IV.—Tabulation of Data for the Entire 1932 Experiments.

Bait No.	1	2	3	4	5	6	7	Average for Rep.
Rep. No.								
1	50.4	51.4	60.6	48.7	59.8	47.2	64.0	54.5
2	40.7	38.8	60.0	43.8	41.8	47.2	39.0	44.4
3	33.5	32.1	36.3	29.8	36.5	27.2	32.9	32.6
4	45.5	41.3	52.2	45.3	37.0	39.1	41.3	43.1
5	19.7	38.3	23.6	37.6	38.5	36.0	25.3	31.3
6	43.8	46.1	38.5	36.2	44.0	36.1	38.3	40.4
7	64.0	81.1	78.4	69.3	68.0	64.0	62.9	69.9
8	69.0	80.0	70.4	65.2	70.1	61.3	73.9	69.9
9	69.6	62.3	51.6	47.3	59.6	64.1	71.4	60.8
10	70.0	57.1	45.4	52.0	56.6	60.9	58.4	57.2
11	33.3	28.5	42.8	41.6	34.7	35.7	33.3	35.7
12	71.9	70.8	75.0	62.1	70.6	72.0	79.5	71.7
Average for Rep.	50.9	52.3	52.9	48.2	51.4	49.2	51.6	50.9

SUMMARY OF 1932 TESTS OF ATTRAHENTS.—In Table V the baits are listed according to their average kill for the 12 replicates. All have been compared with Bait 3, the one giving the highest average.

Table V.—List of Baits and Elimination Level for 1932 Experiments.

Bait No.	Average kill	Difference	S. E. Difference	Diff./S. E.
3	52.9±2.43	.. ..	.. ....	.. ....
2	52.3±2.41	.6	3.42	.. ....
7	51.6±2.37	1.3	3.39	.. ....
5	51.4±2.36	1.5	3.38	.. ....
1	50.9±2.34	2.0	3.37	.. ....
6	49.2±2.27	3.7	3.32	1.14
4	48.2±2.22	4.7	3.29	1.42

There is no significant difference between any of the seven baits tested. This does not quite equal the results obtained in 1931, in which there were two baits which gave a significance over Bait 1. This may be accounted for largely by the fact that the area in which these baits were tested in 1932 was unusually dry. Dryland conditions were so closely simulated that the moisture in the baits became the governing factor. This had a tendency to equalize the attractiveness of all baits and the effect of the attrahents was not so well defined. Other baits ranked about as they did in 1931. Bait 7, which contained dried beet pulp in place of bran, ranked third this year, as against eleventh last year. This was probably due to the fact that beet molasses was added. The fact that salt was omitted from this bait in 1932 may have added to its effectiveness.

EXPERIMENTS WITH POISONS IN GRASSHOPPER BAITS

These experiments were undertaken to test the efficiency and rate of kill of some of the more popular toxic agents in grasshopper baits.

MATERIALS.—The materials selected were mixed in the proportions given below with a basic formula of bran 100 pounds, beet molasses 2 gallons, amyl acetate 3 ounces and water 14 gallons.

Bait 1 Basic formula 4 pounds sodium fluosilicate
Bait 2 Basic formula 2 pounds dry sodium arsenite
Bait 3 Basic formula 1 quart liquid sodium arsenite (8-pound material)
Bait 4 Basic formula 4 pounds paris green.

METHODS.—The tests were conducted in the same manner as described under the 1931 experiments, except in the counting of the dead hoppers. Counts were made at 12-hour intervals following the first 24 hours after the baits had been scattered. There was no control cage included in this series of baits.

EXPERIMENTAL RESULTS.—Table VI gives the results of the 12-hour counts. The calculations are based on the total dead for each treatment for the seven replications.

Table VI.—Tabulation of Results from the 12-Hour Counts.

	Number of hours after poisoning												
	24		36		48		60		72		84		
Bait No.	Total kill	Pct. klil	Total kill	Pct. kill	Total kill	Pct. kill	Total kill	Pct. kill	Total kill	Pct. kill	Total kill	Pct. kill	Total Dead
1	34	9.6	184	52.2	30	8.5	53	15.0	12	3.4	39	11.0	352
2	11	3.1	180	52.3	35	10.1	79	22.9	12	3.4	27	7.8	344
3	41	9.4	216	50.0	32	7.4	84	19.4	9	2.0	50	11.5	432
4	33	8.2	252	63.3	39	9.8	52	13.0	8	2.0	14	3.5	398

The numbers in the lefthand column under the 12-hour intervals, represent the total that died during that period for the entire experiment. The numbers in the righthand column represent the percentage.

There is little difference in rate of kill between any of the first three baits. Each gave its highest kill during the first 36 hours. The next highest was evident during the 60-hour period. Bait 4, containing paris green, likewise gave its highest percentage of kill during the first 36 hours. This was also somewhat higher than any of the other baits. During the 60-hour period Bait 4 fell considerably below the other baits. This was true also of the 84-hour period.

These data tend to show that paris green, used at the rate of 4 pounds to 100 pounds of bran, kills somewhat quicker than any of the other poisons used. This fact may be of importance in protecting gardens where quick action is sometimes necessary.

Table VII shows the ranking of the various baits with relation to their average kills for the experiment.

Table VII.--List of Baits and Elimination Level.

Bait No.	Average kill	Difference	S. E. Difference	Diff./S. E.
4	96.1±3.01	....	.. ....	.. ....
3	88.8±3.33	7.3	4.90	1.48
2	86.1±3.24	10.0	4.84	2.06
1	82.3±3.09	13.8	4.75	2.90

Bait 4, paris green, shows a significance over Bait 1 and possibly 2, but apparently is no better than Bait 3. Bait 3, on the other hand, would not be significantly better than either 1 or 2. Bait 1 gave the poorest results of any of the four baits.

CONCLUSIONS

It was definitely shown by the experiments in 1931 that grain screenings, mill sweepings and other waste material, cannot be used as substitutes for bran. Salt was found to be unnecessary in the grasshopper bait for Colorado.* Dried beet pulp has possibilities as a substitute for bran.

The results of the experiments of 1932, altho not as outstanding as those of 1931, do more or less substantiate them. Amyl acetate was again found unnecessary in the cane-molasses bait, but may be used to advantage in combination with beet molasses. Dried beet pulp, when mixed with beet molasses and amyl acetate, gave as good results as bran for this particular year.

Paris green kills a little quicker than either of the sodium arsenites or sodium fluosilicate. It may also give a higher percentage of kill. In price both paris green and sodium fluosilicate are much high-

*Statistically baits containing amyl acetate show no advantage over baits not containing it, but there are slight indications that it may have some advantage when used in combination with beet molasses.

er than the sodium arsenites. This fact should almost exclude their use in large campaigns. Of the two sodium arsenites, the liquid is probably slightly cheaper. The difference however, might well be made up in additional freight if the material must be shipped any great distance, since the equivalent of 2 pounds of the dry material, in the liquid, weighs 4½ pounds.

After all, the formula which is to be used in the various states will vary according to the materials available. In Colorado beet molasses is plentiful and cheap, while cane molasses is high in comparison. Even the additional expense of amyl acetate does not warrant the use of cane molasses. In those states where cane and beet molasses are approximately the same price, it would probably be advisable to use the cane. In some dryland sections it is doubtful if either will give enough additional results to warrant their use.

Sawdust, which has been used successfully in some states, would be out of the question in Colorado, where a large supply is not readily available. The cost of shipping it in would prohibit its use.

The results of the 2 years' work reported on in this bulletin would indicate the following formulae for Colorado:

For Irrigated Lands

No. 1	Bran	100 pounds
	Beet molasses	2 gallons
	Amyl acetate	3 ounces
	Sodium arsenite, liquid 8-pound material	1 quart
	Water	10 to 12 gallons
No. 2	Bran	100 pounds
	Beet molasses	2 gallons
	Amyl acetate	3 ounces
	Sodium arsenite (dry)	2 pounds
	Water	10 to 12 gallons

For Dryland

Bran	100 pounds
Sodium arsenite (liquid)	1 quart
Sodium arsenite (powder)	2 pounds
Water	10 to 12 gallons

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