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CACTUS SOLUTION AS AN ADHESIVE IN ARSENICAL SPRAYS FOR INSECTS.[1]

By M. M. High,
Entomological Assistant, Truck Crop and Stored Product Insect Investigations.

INTRODUCTION.

In the application of arsenical sprays against insects with biting mouth parts the object in view is, of course, to protect the plant or plants from insect ravages by poisoning the foliage, so that the insects will, in feeding, take into their system enough of the poison to produce death. Some arsenicals, because they possess a higher percentage of free arsenic, act more quickly in this direction than others, but these are, as a rule, injurious to most plant foliage, unless mixed with some agent that will counteract the free arsenic and produce a more uniform distribution on the plants sprayed. Arsenicals containing a high percentage of arsenious oxid generally possess only slight adhesive powers and after a heavy dew or light rain are washed from the foliage.

Certain crops demand very prompt protection from the ravages of biting insects; otherwise severe losses are almost certain to be incurred, and to insure the preservation of the crop concerned it is highly important that a poison with some lasting qualities, as well as one quick in action, be applied. Thus it follows that an arsenical must adhere to the foliage if the most favorable results are to be realized.

In 1913 and 1914 some experiments were conducted for the purpose of discovering a good adhesive which could be obtained easily and at little expense to the grower. This adhesive has been found in a cactus that flourishes in the Southwest. The variety which was most extensively used in the following experiments, and

[1] This bulletin describes the use of cactus solution as an adhesive in the application of arsenical sprays against the belted cucumber beetle. It is applicable to regions where prickly pear is easily obtainable and for the treatment of insects of related habits, such as the striped and twelve-spotted cucumber beetles, etc.

one of the most abundant of the many species to be found in the lower Rio Grande Valley, is *Opuntia lindheimeri* Engelm., commonly known as the "prickly pear." This plant produces a fruit that is available about one month in each year and one of which the natives are especially fond. Further, the plants themselves furnish food to many domestic animals and, it is claimed, prevent many cattle from dying during severe droughts because of their highly watery composition. Many ranchmen protect their cacti during a wet season and save them against the time of drought. A gasoline torch, manufactured especially for the purpose, is used to burn off the spines, and as soon as this burner is put into operation cattle, recognizing the peculiar noise, come at once to obtain the food thus rendered available.

The prickly pear, besides being high in fluid content, is very mucilaginous and is invariably used by Mexicans in the manufacture of whitewash, to promote adhesiveness. The cactus is sliced the evening previous to the application and placed in the water or in the lime mixture, where it remains for several hours. The whitewash is then ready for use. The utilization of cactus in whitewash thus suggested to the writer its availability as a factor in promoting adhesion in poisonous sprays.

EXPERIMENTAL WORK WITH CACTUS.

EXPERIMENTS WITH ZINC ARSENITE.

On March 23, 1913, 20 pounds of cactus were sliced lengthwise and immersed overnight in 50 gallons of water. The next morning 2 pounds of zinc arsenite in paste form were added, and after a thorough mixing spraying was commenced on sugar beets which were being injured by the belted cucumber beetle (*Diabrotica balteata* Lec.).[1]

A previous experiment demonstrated that cactus yields a higher percentage of mucilaginous matter if sliced at right angles to the spines, and, moreover, the time required for preparation is materially shortened by this method. It is best, however, to cut the larger pads both ways, since, owing to the cellular structure of the pads, this method insures a more copious and rapid flow of the juices. The result obtained from the use of the spray, at the rate of 20 pounds of prepared cactus to 50 gallons of water, was gratifying; the spray not only adhered to the foliage better, but spread more uniformly over the surface of the leaves. The quantity of cactus required to

[1] Accounts of this species, by Dr. F. H. Chittenden and Mr. H. O. Marsh, have been published in Bulletin No. 82, Part VI, Bureau of Entomology, U. S. Departemnt of Agriculture, pages 69–71 and 76–82, December 8, 1910. These include illustrations of the stages, notes on life history, lists of food plants, and technical descriptions of the different stages.

make 20 pounds is comparatively small. The results of this spraying operation were favorable, as the number of beetles present four days later did not exceed 30 per cent of the original number, and a majority of these had just arrived from near-by breeding quarters.

In the next experiment 10 pounds of cactus were used in combination with 3 pounds of zinc arsenite and 50 gallons of water. As before, the cactus was sliced and placed in water the evening previous to spraying, and the following morning the solid particles were thrown out before the poison was added. This spraying operation, with but 10 pounds of cactus, gave good results, but the spreading quality of the material was not as good as in the first experiment, in which 20 pounds of cactus were employed.

In the next experiment, on April 3, 15 pounds of cactus were used with 3 pounds of zinc arsenite and 50 gallons of water. In this case the poison appeared to adhere and spread as well as when 20 pounds of the cactus were used. It thus appeared that 15 pounds of the cactus with spines[1] would be about the proper proportion to use with 50 gallons of water in future work.

The following table shows the mortality of *Diabrotica balteata* placed on an encaged sugar-beet plant sprayed with zinc arsenite at the rate of 3 pounds to 50 gallons of water plus 15 pounds of prepared cactus:

TABLE I.—*Experiment No. 10.—Cactus as an adhesive in combination with arsenite of zinc, Brownsville, Tex., 1913.*

Date.	Beetles present.	Living.	Dead.	Feeding.	Not feeding.
Mar. 17	5	4	1	4	1
Mar. 18	5	3	2	3	2
Mar. 19	5	3	2	3	2
Mar. 21	5	1	4	1	4
Mar. 22	5	0	5	0	5

The beetles were placed on the sprayed plant at 6.30 p. m., March 15, but during several cool days which followed they were quite inactive and probably fed but little. Cactus was tested in the insectary as an adhesive before experiments were conducted in the field, to insure the absence of any inopportune chemical reaction that might injure the plants. This experiment demonstrated that in approximately six days after spraying 99 per cent of the beetles succumbed to the poison. Simultaneously with the foregoing experiment another

[1] Cactus with spines is preferable to the spineless varieties; in fact, the spiny variety appears to be nearly one-third richer in gluten. The Dairy Division of the Bureau of Animal Industry has been conducting some cactus-feeding experiments for dairy cows the past two years, and has made several analyses of both the spined and spineless varieties of cactus.

pot experiment was made, discarding cactus and using the same amount of arsenite of zinc. The following results were obtained:

TABLE II.—*Experiment No. 11.—Arsenite of zinc without cactus as an adhesive, Brownsville, Tex., 1913.*

Date.	Beetles present.	Living.	Dead.	Feeding.	Not feeding.
Mar. 17	7	6	1	6	1
Mar. 18	7	4	3	4	3
Mar. 19	7	4	3	2	5
Mar. 21	7	3	4	3	4
Mar. 22	7	3	4	1	6

It will be noticed here that at the end of the sixth day the mortality was much under that of experiment No. 10. The plants in both experiments were sprayed thoroughly, but the latter spray did not spread as well as the former. In the next experiment cactus was again used at the rate of 20 pounds to 50 gallons of water. The same amount of zinc arsenite was used in this experiment, or 3 pounds to 50 gallons of water. Table III shows the number of deaths on each date.

TABLE III.—*Experiment No. 12.—Cactus as an adhesive in combination with arsenite of zinc, Brownsville, Tex., 1913.*

Date.	Beetles present.	Living.	Dead.	Feeding.	Not feeding.
Mar. 17	14	8	6	6	8
Mar. 18	14	3	11	2	12
Mar. 19	14	3	11	1	13
Mar. 21	14	0	14	0	14
Mar. 22	....	0	....	0	....

The beetles were placed on the poisoned sugar beet at 6 p. m., March 15, and in 36 hours nearly all of them were dead.

EXPERIMENT WITH PARIS GREEN AND LIME.

In the next pot experiment Paris green was used in place of zinc arsenite and at the rate of one-half pound to 50 gallons of water plus 2 pounds of lime. The plant was sprayed on March 17, and as soon as the poison was dry on the sugar beet the beetles were liberated inside the cage. Table IV sums up the results.

TABLE IV.—*Experiment No. 13.—Cactus as an adhesive with Paris green and lime, Brownsville, Tex., 1913.*

Date.	Beetles present.	Living.	Dead.	Feeding.	Not feeding.
Mar. 18	10	10	0	6	4
Mar. 19	10	2	8	2	8
Mar. 21	10	0	10	0	10
Mar. 22	10	0	10	0	10

The cucumber beetle appeared, as will be seen from the foregoing table, to succumb more readily to the Paris-green spray than to any one of the former sprays of zinc arsenite. In the field experiments there was not much difference, though the zinc arsenite gave more favorable results in that it lasted longer. The dews in the lower Rio Grande Valley are usually heavy ones, which would naturally reduce the effectiveness of the Paris-green application. But, as already shown, in the pot experiment the results appeared much more quickly than with the other sprays.

UNSATISFACTORY RESULTS WITH LEAD ARSENATE.

Since the experiments with cactus as an adhesive and a spreader for zinc arsenite and for Paris green and lime had resulted so favorably, not only in increasing the adhesiveness of the spray, but also in the destruction of the beetle, it was decided to try it in combination with lead arsenate. The cactus was placed in a barrel of water about 12 hours before the arsenate of lead was added. A few minutes after adding the lead arsenate the formation of a precipitate was observed. In an hour's time a cottony scum had formed on the surface and appeared fairly well distributed throughout the mixture. In the meantime spraying had been going on, but with little success, as this semiliquid matter clogged the nozzles. In about two hours' time the precipitation was more complete and the solution was discarded, since its consistency rendered it useless for spraying purposes. Alkalinity of the water was at first suspected, and rain water was substituted, but with the same results, so that no further attempt was made to use the cactus with lead arsenate. The lead arsenate employed was air-dried, having been formerly paste which had dried out in an open keg; but no doubt even with fresh arsenate of lead the same precipitation would have taken place, as the air-dried arsenical had been used successfully without the cactus and had remained in solution, although it did not adhere well.

In experiment No. 14 (Table V) arsenate of lead was employed at the rate of 3 pounds to 50 gallons of water. As the potted plant was quite small, there was not sufficient foliage to support a great number of beetles, and on April 4, at 6 p. m., six belted cucumber beetles were placed on the plant.

TABLE V.—*Experiment No. 14.—Cactus as an adhesive with arsenate of lead. Brownsville, Tex., 1913.*

Date.	Beetles present.	Living.	Dead.	Feeding.	Not feeding.
Apr. 6	6	5	1	4	2
Apr. 7	6	5	1	4	2
Apr. 8	6	4	2	3	3
Apr. 9	6	2	4	2	4
Apr. 11	6	0	6	0	6

The time required to kill all of the beetles placed on the sprayed plant was approximately six days, provided all specimens began feeding immediately after being placed on the poisoned plant.

In the next experiment $2\frac{1}{2}$ pounds of arsenate of lead were used to 50 gallons of water. The host plant was spinach that had been growing in the pot for some time. The spraying was done during the morning of April 14, and at 4 p. m. on the same date, after the poison had dried, 10 belted cucumber beetles were placed inside the cage and on the plant where possible. Table VI shows the mortality:

TABLE VI.—*Experiment No. 15.—Cactus as an adhesive with arsenate of lead, Brownsville, Tex., 1913.*

Date.	Beetles present.	Living.	Dead.	Feeding.	Not feeding.
Apr. 16	10	9	1	7	2
Apr. 17	10	8	2	5	3
Apr. 24	10	2	8	0	8

The spray here used was not so effective as in experiment No. 14, the mortality being only 80 per cent at the end of nine days. The plant died from some cause about the 24th of April, and probably very little feeding was done during the last few days the plant lived after being sprayed.

FURTHER EXPERIMENTS.

The results obtained in the foregoing experiments had been so favorable that further experiments on a larger scale were commenced. Several thousand pounds of the prickly pear were used in the work, and as the regular "pear burner," or torch, was employed to singe the spines from the pads, they could now be handled with some comfort. The work has been conducted in a small way and on a large scale with about the same degree of success. It requires only a short time to burn the spines from enough cactus to make a sufficient amount of adhesive material for several thousand gallons of spray mixture.

The list of insecticides that have been employed in combination with cactus as an adhesive includes Paris green, lead chromate, zinc arsenite (in both paste and powder forms), lead arsenate, ferrous arsenate, and iron arsenite. The preceding pages give an account of experiments with zinc arsenite in the paste form, Paris green, and lead arsenate in the paste form, while the experiments that follow will include zinc arsenite in the powder form, lead arsenate in paste form, ferrous arsenate, and iron arsenite, the last two used in the powder. The powdered zinc arsenite gave excellent results in every instance when used in combination with cactus water, and the mortality was in some cases higher than when three times the weight in paste form was used. Very favorable results were obtained with ferrous arsenate in most cases, while the results with iron arsenite were not quite so good. The following tables give results of the experiments conducted in the insectary with each of the arsenicals here mentioned.

On March 1, 1914, a cabbage plant was sprayed with ferrous arsenate at the rate of 1 pound to 40 gallons of water, and as soon as the poison had dried on the leaves, or at 6 o'clock p. m. the same date, four *Diabrotica balteata* were encaged on the plant.

TABLE VII.—*Experiment No. 16.—Cactus as an adhesive with ferrous arsenate, Brownsville, Tex., 1914.*

Date.	Beetles present.	Living.	Dead.	Feeding.	Not feeding.
Mar. 2	4	4	0	1	3
Mar. 3	4	4	0	0	4
Mar. 4	4	4	0	3	1
Mar. 5	4	4	0	3	1
Mar. 6	4	4	0	3	1
Mar. 7	4	4	0	2	2
Mar. 8	4	4	0	3	1
Mar. 9	4	4	0	2	2
Mar. 10	4	1	1	1	1

It will be seen from the foregoing table that the mortality was much too low to pay for applying the poison. It was observed that the feeding was light for four or five days after confinement. The solution did not adhere and distribute itself well enough to make a good spray.

About the same time that spraying was done on experiment No. 16 a second solution was made up, using the same amount of ferrous arsenate or 1 pound to 40 gallons of water. Eighty per cent of the water used was taken from a tank where two days previous $1\frac{1}{3}$ pounds of cactus to the gallon of water had been placed. This made an exceedingly glutinous solution which caused the liquid to spread uniformly as well as to adhere. On March 2 seven *Diabrotica balteata* were placed on the plant.

TABLE VIII.—*Experiment No. 17.—Cactus as an adhesive with ferrous arsenate, Brownsville, Tex., 1914.*

Date.	Beetles present.	Living.	Dead.	Feeding.	Not feeding.
Mar. 3	7	6	1	3	4
Mar. 4	7	6	1	6	1
Mar. 5	7	6	1	6	1
Mar. 6	7	6	1	4	3
Mar. 7	7	6	1	5	2
Mar. 8	7	6	1	4	3
Mar. 9	7	6	1	3	4
Mar. 13	7	5	2	1	6
Mar. 14	7	5	2	4	3

The death rate in this experiment was very low, which is accounted for to a certain degree by a decrease in the voracious appetite of the beetles, which were encaged on a cabbage plant. Feeding appeared to be more from the underside of the leaves, and usually the epidermis was left intact.

In the next experiment with potted plants spinach was substituted for cabbage, since it seemed preferable to the beetles, particularly as the cabbage plants had been growing for some time in the pots and had become more or less stunted and tough. In this experiment ferrous arsenate was used at the rate of 1 pound to 40 gallons of water, in which 40 pounds of cactus had been placed 72 hours previous. Table IX shows results and mortality. The plant was sprayed April 2, and on April 4 five beetles were liberated on the plant and covered with a lantern globe.

TABLE IX.—*Experiment No. 18.—Cactus as an adhesive with ferrous arsenate, Brownsville, Tex., 1914.*

Date.	Beetles present.	Living.	Dead.	Feeding.	Not feeding.
Apr. 4	5	5	0	4	1
Apr. 5	5	5	0	1	4
Apr. 6	5	5	0	0	5
Apr. 7	5	4	1	0	5
Apr. 8	5	3	2	0	5
Apr. 9	5	2	3	0	5

The results here were much better than in experiments Nos. 16 and 17, and the beetles appeared to succumb more readily, since they fed more rapidly.

On April 6 a spray was made up of ferrous arsenate, using 1 pound to 12 gallons of water in which 10 pounds of sliced cactus had been placed 48 hours previous to spraying, insuring thorough glutinous consistency in the spray mixture. Some spinach plants in pots were sprayed previous to spraying plats in the field. On April 13, or one week from date of spraying, six beetles were encaged on a plant and observed for 10 days. Table X shows the number of beetles that succumbed.

TABLE X.—*Experiment No. 18.—Cactus as an adhesive with ferrous arsenate. Brownsville, Tex., 1914.*

Date.	Beetles present.	Living.	Dead.	Feeding.	Not feeding.
Apr. 13	6	6	0	3	3
Apr. 14	6	4	2	4	2
Apr. 15	6	4	2	4	2
Apr. 16	6	4	3	3	3
Apr. 18	6	4	2	1	5
Apr. 20	6	3	3	2	4
Apr. 21	6	3	3	1	5
Apr. 23	6	3	3	0	6

This plant began to wilt and appear blighted on April 18, little feeding being done from that date, even though the poison had been on the plant for nearly two weeks. It is thought that a higher mortality would have occurred had the plant remained green and living.

An arsenate of lead spray was made, using the paste form at the rate of 4 pounds to 60 gallons of water. In this solution no cactus was used. On April 11 five beetles were placed on an encaged cabbage plant in the insectary that had been sprayed five days before. Table XI gives the final results.

TABLE XI.—*Experiment No. 20.—Arsenate of lead without cactus, Brownsville, Tex., 1914.*

Date.	Beetles present.	Living.	Dead.	Feeding.	Not feeding.
Apr. 13	5	5	0	4	1
Apr. 14	4	3	1	1	3
Apr. 16	4	3	1	1	3
Apr. 18	4	2	2	1	1

This spray did not adhere to the cabbage foliage as well as when cactus was used, and the beetles fed very slowly after the first two days of confinement. Better results were obtained in the field, as the beetles began feeding just after spraying, and where a partial uniform coating was secured the poison was effective. If the poison could be made to combine or mix with cactus water the results would undoubtedly be much better.

April 2 a solution was made up of iron arsenite, using 1 pound to 40 gallons of water. Some difficulty was experienced in bringing the poison into suspension, as it settled quite rapidly to the bottom of the barrel. April 4 another solution was prepared, using the same amount of poison to a given quantity of water, with the previous addition of cactus at the rate of 1¼ pounds to each gallon of water, in which salicylic acid had been used as a preservative to prevent fermentation of the cactus juice. As a check some potted cabbage plants were sprayed. On April 11 ten belted cucumber beetles were encaged on one of the cabbage plants that was sprayed April 4. Table XII gives the results.

TABLE XII.—*Experiment No. 21.—Cactus as an adhesive with iron arsenite, Brownsville, Tex., 1914.*

Date.	Beetles present.	Living.	Dead.	Feeding.	Not feeding.
Apr. 13	10	9	1	7	3
Apr. 14	8	7	1	7	1
Apr. 15	8	7	1	7	1
Apr. 16	2	1	1	1	1
Apr. 18	2	1	1	0	2

It is apparent that although the application had been made for more than a week, a sufficient amount of the arsenical remained to have some effect on the feeding of the beetles. A later experiment with iron arsenite showed the mortality of the beetles when they feed on the plant immediately after spraying has been done.

While spraying a plat of sugar beets at the South Texas Gardens on April 15 the writer also sprayed some plants in the insectary, using zinc arsenite in the powdered form. The cactus was used at the rate of 1.8 pounds to the gallon of water and the zinc arsenite at the rate of 1 pound to 64 gallons. The plants were sprayed on the morning of the 15th, and on April 16 eleven beetles were liberated inside the cage surrounding the plants.

TABLE XIII.—*Experiment No. 22.—Cactus as an adhesive with zinc arsenite, Brownsville, Tex., 1914.*

Date.	Beetles present.	Living.	Dead.	Feeding.	Not feeding.
Apr. 16	11	11	0	8	3
Apr. 17	11	10	1	9	2
Apr. 18	11	10	1	9	2
Apr. 20	11	4	7	4	7
Apr. 21	11	4	7	3	8
Apr. 23	11	1	10	0	11

This spray adhered and spread exceedingly well, although much less cactus could have been used with equal results. However, no precipitation was observed when the cactus was used at this strength.

In experiment No. 23 a potted sugar beet was sprayed April 11 with zinc arsenite (powdered) at the rate of 1 pound to 35 gallons of water, using three-fourths of a pound of cactus to each gallon of water, the cactus having been placed in the water four days before. Fermentation was prevented by the use of copper sulphate. On April 15 ten belted cucumber beetles were encaged on the plant.

TABLE XIV.—*Experiment No. 23.—Cactus as an adhesive with zinc arsenite, Brownsville, Tex., 1914.*

Date.	Beetles present.	Living.	Dead.	Feeding.	Not feeding.
Apr. 16	10	10	0	5	5
Apr. 17	10	10	0	5	5
Apr. 20	8	2	6	2	6
Apr. 21	8	1	7	1	7
Apr. 23	8	0	8	0	8

It will be observed that in this experiment less than half the quantity of cactus was used than was added in experiment No. 22, but the zinc arsenite was increased to nearly twice the amount used in the preceding experiment, and there was only a 10 per cent difference in the mortality. The plants used were both sugar beets. The result of this experiment shows that by the use of cactus the lasting qualities of the poison on the plants may be greatly increased.

The spraying in experiment No. 24 was done at the same time as in experiment No. 22, 1 pound of zinc arsenite being used to 64 gallons of water but only one-third of a pound of cactus to each gallon, the glutinous matter having been extracted by soaking the cactus for four days in water. Salicylic acid was added as a preservative. The sugar beet was sprayed on April 15, and on April 16 five beetles were placed on the plant. April 17 one beetle was found dead and four still feeding. April 18 three had died from the effect of the poison and two were yet feeding. On April 20 all were dead. During the four days the beetles were encaged they appeared to feed very rapidly, as they had been confined for several days without food. This proves that 1 pound of powdered zinc arsenite with cactus to make it adhere is more effective than 2 pounds in the paste form and just as effective as 3 pounds in the paste form.

The plant in experiment No. 25 was sprayed with 1 pound of zinc arsenite to 35 gallons of water and at the same time as No. 23, on April 11, with the same quantity of cactus, but the beetles were not placed on the plant for six days after spraying. On April 17 three beetles were encaged, and by the 22d all were dead.

On April 5, after spraying a field plat of cabbage with ferrous arsenate, several plants were treated in the insectary. The strength used was 1 pound to 12 gallons of water. One pound of cactus was used to each gallon of water, the cactus water having been made 26 days when used. It was prepared on March 16 and sodium benzoate added as a preservative. On April 11 six beetles were placed on a cabbage plant covered by a lantern globe. Table XV gives the number of beetles that succumbed in a given period.

TABLE XV.—*Experiment No. 26.—Cactus as an adhesive with ferrous arsenate. Brownsville, Tex., 1914.*

Date.	Beetles present.	Living.	Dead.	Feeding.	Not feeding.
Apr. 13	6	6	0	4	2
Apr. 14	6	6	0	5	1
Apr. 15	6	6	0	5	1
Apr. 16	6	6	0	1	5
Apr. 17	6	3	3	2	4
Apr. 18	5	1	4	1	4
Apr. 20	5	1	4	1	4
Apr. 21	5	0	5	0	5

The beetles from some cause fed very sparingly the whole time they were encaged. Whether the poison was distasteful or the plant had become tough, could not be ascertained.

On April 4 a small plat of cabbage was sprayed with iron arsenite at the rate of 1 pound to 40 gallons of water. Two pounds of cactus were added to each gallon and the decoction was prepared on March 14 and 15. It was preserved with salicylic acid at the rate of ¼ pound to 50 gallons. It was quite difficult to bring the arsenite of iron into suspension. Thorough agitation was required to prevent it settling to the bottom of the tank. With a hand sprayer it is impossible to secure uniformity in the spray. Table XVI gives results with 10 beetles on one cabbage plant sprayed on April 4, the beetles being liberated on the plant April 11.

TABLE XVI.—*Experiment No. 27.—Cactus as an adhesive with iron arsenite, Brownsville, Tex., 1914.*

Date.	Beetles present.	Living.	Dead.	Feeding.	Not feeding.
Apr. 13	10	10	0	10	0
Apr. 14	10	9	1	8	2
Apr. 16	10	9	1	6	4
Apr. 17	10	9	1	6	4
Apr. 18	10	8	2	7	3
Apr. 20	10	8	2	4	6
Apr. 21	9	6	3	6	3
Apr. 23	9	5	4	5	4

Feeding was very heavy on this plant, which had been growing for some time in the pot and had been seriously attacked by aphides on two occasions. Iron arsenite has some value as an insecticide, but not as much as ferrous arsenate, even when properly made up, and unless an effort is made to apply it in uniform coating on the foliage it has little value as an insect destroyer.

CACTUS COMPARED WITH WHALE-OIL SOAP AS AN ADHESIVE.

On February 20, 1914, while conducting spraying experiments against the belted cucumber beetle and cabbage looper (*Autographa brassicæ* Riley) on cabbage on the farm of Mr. George Federhoff, near Brownsville, Tex., it was decided to make a comparison of whale-oil soap and cactus as adhesives, without considering the cost of the two products. One acre of cabbage was sprayed with 1 pound of zinc arsenite (in powdered form) to 60 gallons of water, with the addition of 35 pounds of cactus. The cactus was sliced and put in the water on February 19, and had given up its glutinous matter to the solution by the time spraying was begun the following day. This mixture spread and adhered exceedingly well. The next acre was sprayed with the same amount of poison, but whale-oil soap was substituted for cactus. This was done both for a comparison of adhesive qualities and to observe the effect of the soap on the cabbage aphis (*Aphis brassicæ* L.), as in several spots in this acre the aphis was making its appearance. The soap was used at the rate of 3 pounds to 60 gallons of water. Very careful notes were made on the sticking qualities of the soap, and it was found that when compared at close range with the cactus spray the soap equalled the cactus in spreading power, although lacking in adherence. This information was obtained by observing sprayed plants with and without a lens. It was soon seen that the cactus spray adhered and dried on the foliage better than the soap spray. This favored the cactus, since the heavy dews in the Rio Grande Valley will wash poison having but slight adhesive qualities from the foliage in a short time.

COPPER SULPHATE AS A PRESERVATIVE FOR THE CACTUS.

On April 6, 1914, 50 pounds of cactus were cut into small pieces and placed in a barrel with 24 gallons of water, and on April 7, 1 pound of copper sulphate was dissolved in 4 gallons of water and added to the barrel which was numbered lot 6.

The solid portion of the cactus or prickly pear was removed before adding the copper sulphate. This made 28 gallons in solution. No chemical action was observed. The solution kept perfectly for about four weeks, when it had to be discarded to make room for other experiments. The temperature during this time averaged about 70° F.

COPPER SULPHATE USED WITH ZINC ARSENITE.

After using the copper sulphate as a preservative for the juice extracted from the prickly pear, the possibility of a chemical reaction upon the addition of the arsenical to the solution was tested. Upon the addition of powdered zinc arsenite at the rate of 1 pound to 60 gallons of water a slight chemical reaction was noticed, evidently the copper changing places with the zinc to a small degree. A slight precipitate was formed, but not enough to cause any trouble when a good pressure was maintained in the tank of the sprayer. The precipitate was not increased after the mixture was allowed to stand for three hours. No difference was observed in the effectiveness of the arsenical, either with or without the addition of the copper sulphate.

COPPER SULPHATE USED WITH LEAD ARSENATE.

The use of lead arsenate in combination with prickly pear without the addition of some other chemical has never been a success. A precipitate is always formed which makes it impossible to use the mixture to advantage as a spray. The same proportion of cactus and copper sulphate utilized in the zinc arsenite spray was here employed. On April 13, 1914, 1 pound of lead arsenate in the paste form was placed in 20 gallons of cactus water which contained copper sulphate in the amount of 1 pound to 28 gallons of water. It was at once noticed that the copper sulphate retarded the precipitation of the lead arsenate, so much so that the solution could be used as a spray with some success, at a normal pressure with a hand pump. This was encouraging, as it had been impossible to use lead arsenate alone in combination with cactus as an adhesive. The writer would recommend, however, that the foregoing combination be used on a large scale only when a strong pressure can be maintained throughout the operation, or the results will be unsatisfactory.

The mortality in the experiments was practically the same as when the arsenical was used alone. Had more experiments been made in the field, in all probability a higher mortality would have been observed in the end.

COPPER SULPHATE AND FERROUS ARSENATE.

The use of copper sulphate as a preservative for the cactus, combined with ferrous arsenate to form a spray, did not appear to produce any chemical changes, no noticeable precipitate being found that would prevent the use of the solution as a spray. It had been expected that more of an action would take place when the ferrous arsenate was added to the cactus water containing copper sulphate. The ferrous arsenate was not altered in insecticidal value when mixed with sulphate of copper.

EXPERIMENTS WITH OTHER PRESERVATIVES.

SALICYLIC ACID.

On March 13, 1914, 45 pounds of cactus were sliced and placed in 32 gallons of water, and in another lot 30 pounds were added to 24 gallons of water. The following day the solid portion of the cactus was removed from the two lots and the water poured from both into another receptacle. This made 56 gallons of the liquid to be preserved. One-fourth of a pound of salicylic acid was dissolved and added to the cactus water, and the mixture was allowed to stand exposed to the air. On April 1 the mixture was found to be in perfect condition. A bluish-white scum was noticed to have formed on the surface shortly after the acid was dissolved in the water. To dissolve salicylic acid a certain amount of alcohol is necessary. At first the acid was dissolved in a 10 per cent solution of alcohol, but it was later found that cactus water served equally well for this purpose after fermentation was well under way, although action was somewhat delayed.

SODIUM BENZOATE.

Sodium benzoate was used in a limited way as a preservative for the cactus solution. On March 14 one-fourth of a pound was dissolved in a small quantity of alcohol and added to a barrel containing 40 gallons of water in which 50 pounds of cactus had been placed March 13, after removing the solid portion of the pear. The mixture was stirred vigorously for five minutes and later covered. On April 2 an examination was made and the liquid used as a spray with zinc arsenite. Only slight fermentation had taken place, and no difficulty was encountered in applying the spray.

The first disadvantage in using sodium benzoate for such a purpose is its cost. It is somewhat more expensive than other chemicals of this class, and the element of cost is a primary consideration. Another feature is that it is not easily dissolved, and unless it is thoroughly dissolved its powers as a preservative are considerably lessened.

On April 2 sodium benzoate was again used in the proportion of 1 pound to 200 pounds of cactus in 100 gallons of water. This was quite a concentrated mixture, but it kept in perfect condition for two weeks, at the end of which time it was used up. The average temperature a part of the time was 80° F.

THE COMMON PRICKLY PEAR CACTI AND THEIR CHEMICAL COMPOSITION.

The common cactus or prickly pear of southern Texas is a variety known as "nopal" or "nopal azul" (*Platopuntia lindheimeri* Engelm.). This is the variety with flat, rounded leaves and growing about 4 or 5 feet high, and it is found well distributed over southern Texas. It is a native species which varies considerably in coloration of spines as well as in its general habit of growth. The fruit is purplish throughout, more so than the more spiny variety, *Platopuntia engelmannii* Salm., which is very similar in habit of growth, but usually occurs farther west than the region occupied by this species. The large spineless cactus frequently cultivated, but ordinarily not occurring abundantly in the cactus plains of southern Texas, is a species which has been called *Platopuntia tuna* Will. It grows much taller than the common "nopal" and is known in California as "mission pear" and in Texas as "Nopal de castilla." It frequently grows 10 to 15 feet in height, with the trunk 12 inches in diameter, and the joints in shape are more elliptical than rounded. The fruit is considerably larger than that of the common "nopal" and greenish throughout.

The chemical analyses of these plants, taken from Bulletin No. 60 of the New Mexico Agricultural Experiment Station,[1] are as follows:

TABLE XVII.—*Chemical analysis of Platopuntia lindheimeri.*

	Green.			Air dry.		
Sample No.	7515	7516	7567	7515	7516	7567
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Spines	0.10	....	0.42	0.72	....	2.60
Water	87.36	79.88	84.82	5.65	5.20	6.55
Ash	2.82	4.98	2.27	21.05	23.45	13.95
Crude protein	.60	.45	.96	4.49	2.12	5.92
Crude fat	.26	.20	.30	1.95	.95	1.82
Nitrogen free extract	7.54	9.55	9.84	56.26	44.98	60.61
Crude fiber	1.42	4.94	1.81	10.50	23.30	11.15
Organic matter	9.82	15.14	12.91	73.30	71.35	79.50

ANALYSIS OF THE ASH.

[Sample No. 7515.]

Carbon .... per cent..	0.14
Sand .... do....	.29
Per cent in pure ash:	
Soluble silica (SiO)	.43
Iron (Fe)	.20
Aluminum (Al)	.00
Manganese (Mg)	.49
Potassium (K)	14.22
Sodium (Na)	.35
Phosphoric acid radicle (PO_4)	1.11
Sulphuric acid radicle (SO_4)	1.15
Chlorine	2.15
Carbonic acid radicle (CO_3)	49.12

TABLE XVIII.—*Chemical analysis of Platopuntia engelmannii.*

	Green.				Air dry.			
Sample No	65621	6575	7810	78411	65621	6575	7810	78411
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Spines	....	0.32	0.04	....	....	3.33	0.33	....
Water	89.09	91.07	89.41	85.41	6.20	7.33	6.83	3.97
Ash	.91	2.00	1.60	.77	7.80	20.80	14.05	5.07
Crude protein	.48	.32	.35	.46	4.16	3.29	3.07	3.06
Crude fat	.33	.12	.23	.33	2.85	1.20	2.00	2.20
Nitrogen free extract	7.31	4.95	7.21	10.03	62.84	51.43	63.48	72.58
Crude fiber	1.88	1.54	1.20	3.00	16.15	15.95	10.57	13.12
Organic matter	10.00	6.93	8.99	13.82	86.00	71.87	79.12	90.96

TABLE XIX.—*Chemical analysis of Platopuntia tuna.*

	Green.		Air dry.	
Sample No	7519	7577	7519	7577
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Spines	0.36	....	1.82	....
Water	81.86	92.25	5.18	8.12
Ash	4.29	1.75	21.65	20.80
Crude protein	1.32	.63	6.68	7.53
Crude fat	.28	.16	1.40	1.85
Nitrogen free extract	8.88	4.02	44.56	47.60
Crude fiber	4.07	1.19	20.53	14.10
Organic matter	14.55	6.00	73.17	71.08

[1] Griffiths, David, and Hare, R. F. Prickly pear and other cacti as food for stock, II. N. Mex. Agr. Expt. Sta. Bul. 60, 134 p., 7 pl., November, 1906.

SUPERIORITY OF CACTUS FROM DRY LAND.

It has been found that cactus growing near resacas and in low wet places yields less glutinous matter to the gross pound than it does when growing on high dry soil. Thus time is saved in making up a spraying solution if the cacti are collected from the higher regions, and not in or near standing water.

On April 13, 1914, 75 pounds of cactus were placed in 40 gallons of water. Twenty-four hours later the cactus was removed and allowed to drain for about one-half hour. It weighed 85.5 pounds, or 10½ pounds more than when placed in the water. Another lot of 110 pounds was increased in weight to 124 pounds by leaving it in water 24 hours. However, when the cactus is sliced and allowed to remain in water until fermentation is well under way, there will be a slight decrease in weight. This will not happen where a preservative is used.

ADVANTAGES IN THE USE OF CACTUS AS AN ADHESIVE.

By the use of cactus as an adhesive not only do the arsenicals give better and more lasting results, but considerable expense may be saved in another way. In the Southwest, where all insecticide material must be shipped in from a great distance, the expense of transporting this material is often more than the cost of the insecticide itself, so that material of a poor quality is often used instead. For some years arsenicals in the paste form have been extensively used by fruit and truck growers on account of their better adherence and lasting qualities, but where a good adhesive is used the writer much prefers arsenicals in the powder form. In conducting experiments in the insectary and in the field at no time have the powdered arsenicals proved less effective, and at times the mortality would be considerably above that shown in another experiment conducted at the same time with arsenicals in the paste form. Better results have been obtained in using 1 pound of zinc arsenite in powder form with cactus than by the use of 3 pounds in the paste form to the same amount of water. Thus equal results may be obtained, with a reduction of 66 per cent in express and freight charges paid in securing arsenicals from a distance.

QUANTITY OF CACTUS TO USE.

The amount of cactus that may be used with good results varies with the environment under which the plants have been growing. If the plants have been growing in or near water it will be necessary to increase the quantity of cactus used to each gallon of water. In general, the correct proportion will range from ⅓ pound to 1 pound to every gallon of water used in making up the spraying mixture. These proportions have given the most favorable results in all experiments conducted so far. When amounts in excess of 1 pound to each gallon of water are used the adhesive powers do not appear to be increased to any great extent, and on the other hand difficulty is experienced in applying the spray, particularly where very fine nozzles are employed.

ZINC ARSENITE AS AN INSECTICIDE.

Zinc arsenite has been used both in the paste and powder forms with much success for the belted cucumber beetle, as well as for some other insects of this class. It has proved to be one of the most effective sprays for use in humid climates, as it appears to last longer. No other arsenical has given better results, and in the majority of cases the mortality has been higher than with any other arsenical spray. The powder when used with cactus to make it adhere is to be preferred for general use over any arsenical now on the market. This spray in the writer's opinion surpasses in lasting qualities any of the arsenicals and at the same time gives a higher mortality. In action it is somewhat slower than Paris green, but it gives better results in the end. The writer would not recommend, however, that zinc arsenite be used on plants that are nearly ready for market, for the poison does not wash off easily.

FERROUS ARSENATE AS AN INSECTICIDE.

Ferrous arsenate has given very good results in combination with cactus to increase its adhesive powers. No serious effects from its use on the most delicate foliage have been observed. The cost of the product at the present time places it beyond general use as an insecticide. The ferrous arsenate in the powder form is very easily brought into suspension, requiring less time than some of the other arsenicals now more extensively used to destroy biting insects. Another feature in the use of this arsenical is that it remains in suspension exceedingly well and settles very slowly to the bottom of the tank. This makes it a most desirable poison for use with small sprayers not equipped with agitators.

IRON ARSENITE AS AN INSECTICIDE.

Iron arsenite was given a trial against the belted cucumber beetle only, and was found to give varying results. The powder was made into a spray and applied both with cactus as an adhesive and without the cactus. The iron arsenite is quite hard to bring into suspension and soon settles to the bottom of the spray tank unless constantly agitated. Its effectiveness as an insecticide was disappointing; in fact, it is so low that it is doubtful that this arsenical can ever come into general use as a spray. Much difficulty was experienced in obtaining uniform distribution over the surfaces sprayed, even when used with cactus. The cactus increased its adherence and spraying qualities, but not sufficiently to remedy matters completely. The foregoing experiments show its effectiveness as compared with ferrous arsenate, zinc arsenite, lead arsenate, and Paris green.

FINAL RESULTS FROM SPRAYING.

The pot experiments carried on in the insectary for the belted cucumber beetle and the other species concerned were undertaken to assist in checking up results in the field. They served for more than this, however, for in a short time it was possible to accumulate much data as to the effectiveness of each spray that otherwise could not have been secured in nearly so short a time, while the estimates as to mortality in each of the experiments made would have been much less conservative.

It was found that the beetles could be best controlled by spraying with zinc arsenite or with Paris green. The other arsenicals employed, while effecting a control in most cases, did not give as high mortality as the two arsenicals mentioned. The number of applications rendered necessary varied with the location of the sugar beets, i. e., their distance from crops where the beetles were breeding in large numbers. One plat of sugar beets was sprayed only once, while on the other hand several plats of beets, spinach, and cabbage were sprayed from two to four times in order to prevent the crop from being badly stunted in growth. The greatest damage is done from the time the beets begin coming up until the leaves have reached a height of 10 inches. Attention should be given the crop from the time the seeds are planted, in order that no serious damage may be done before remedial measures can be put to practice.

RECOMMENDATIONS FOR CONTROL.

The control of such pests as the belted cucumber beetle does not require the attention necessitated by some of the noxious caterpillars and sucking insects. But to keep the injury down to the minimum frequent observation should be made while the plants are small, as this is the time when the beetles are capable of doing the greatest amount of damage.

If the beetles are present in sufficient numbers partially to defoliate a few plants, it is time to begin spraying. It may be necessary to spray only once in order to effect control, but this will depend upon the surrounding vegetation as well as upon the weather conditions.

Any of the arsenicals may be used in the form of a spray to control this beetle. If arsenite of zinc in paste form is to be used, the writer will recommend 3 pounds to 50 gallons of water, in combination where possible with some adhesive, in order that best results may be obtained. In the Southwest the prickly pear serves the purpose best, because better results have been obtained where it was used than with any one of several other adhesives. From an economic standpoint, also, it has first rank as an adhesive and spreader. It has been ascertained that zinc arsenite in the powder form in the proportion of 1 pound to 50 gallons of water in combination with cactus gives a little higher mortality than 3 pounds in the paste form, and a more extensive use of this powdered form is to be recommended, particularly in the cactus-growing region or where the glutinous matter of this plant can be had for use in the spray.

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