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TEXAS AGRICULTURAL EXPERIMENT STATION

A. B. CONNER, DIRECTOR

COLLEGE STATION, BRAZOS COUNTY, TEXAS

BULLETIN 575 JUNE 1939

DIVISION OF AGRICULTURAL ENGINEERING

Prickly Pear Eradication And Control

AGRICULTURAL AND MECHANICAL COLLEGE OF TEXAS

T. O. WALTON, President

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Singed prickly pear has been used by ranchmen as an emergency feed during adverse range conditions since the beginning of the livestock industry of the Southwest. Some livestock (sheep, goats, and cattle) become chronic "pear-eaters," but the losses sustained were not serious until the ranges were overstocked and screw worm cases from prickly pear wounds became numerous. Heavy losses of sheep and goats resulting from injuries to their mouths from eating prickly pear and subsequent screw worm infestations have caused a general desire to eradicate this plant on the ranges.

Experiments since 1933 have shown that grubbing, which includes piling, and poisoning are the most economical methods of eradication. Grubbing can be done at a cost ranging from 25 cents to $3.00 an acre, and poisoning from 25 cents for lightly-infested areas to $2.50 or $3.00 for heavily-infested areas.

Neither the practice of singeing off the spines then grazing nor injury from insects and diseases can be considered as eradication methods, because they do not completely destroy the pear.

The most effective poison consists of a solution of 3 pounds of arsenic pentoxide (96 to 98 per cent pure) to 1 gallon of water, to which is added 1 pint of commercial sulphuric acid. Best results are obtained when this poison is sprayed on both sides of the slabs and the terminal joints in a fine, foglike mist. On the other hand, a heavy rainlike spray is wasteful, because part of the poison will drop off on the ground. A special atomizer using from 110 to 120 pounds of air pressure is used in applying the poisons.

Best results are obtained when poisoning is done during the hot summer months. Poison carefully applied from May to October, inclusive, should give good results. A second application should be made if rain occurs within 24 hours after spraying.

A metal alloy of 18 per cent chromium, 8 per cent nickel, and not over 0.07 per cent carbon, generally termed 18-8-S stainless steel, showed practically no corrosion after a 31-day test when the metal was partly immersed in the prickly pear poison. It appears that this alloy is suitable for the construction of the atomizer tanks.

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PRICKLY PEAR ERADICATION AND CONTROL

By W. H. Dameron, Superintendent, Substation No. 14, Sonora, and H. P. Smith, Chief, Division of Agricultural Engineering.

Ranchmen of West Texas have used prickly pear as a stock food for many years, but during the past decade they have found that livestock often become habitual "pear-eaters." Such animals spend all of their time grazing on prickly pear and fail to get enough food elements by not eating other vegetation until they soon become emaciated and develop scours. Frequently large balls of fibrous material form in the stomach and cause the animals to die.

Sheep and goat raisers of the Edwards Plateau region noticed a few years ago that their sheep and goats began eating the flower buds early in the spring and continued eating the buds, flowers, and young apples until the entire crop had been eaten up. Eating these spiny parts of the cactus plants frequently caused sore mouths, and these sores were ready access for screw worms, making it necessary for the sheepmen to work their stock often and treat all screw worm cases. The Sheep and Goat Raisers Association became interested in the study of methods of control and eradication of prickly pear about 1932, and the president of the association appointed a committee of three, consisting of E. K. Fawcett of Del Rio, V. I. Pierce of Ozona, and W. C. Bryson of Uvalde, to study the situation and take the matter up with the Texas Agricultural Experiment Station.

In January, 1933, the Experiment Station began a study of the various methods of controlling and eradicating prickly pear. A special sprayer developed for applying poisons on prickly pear in Australia was imported and used in the study. Other equipment for injecting poisons into the prickly pear was developed by the Station. The results of these studies are reported in this bulletin.

During the time this study has been in progress, ranchmen throughout the ranching section of the State have become alarmed about the spread of mesquite brush, cedar, and other noxious plants. Some data have been collected regarding the eradication of these plants, but they are not complete enough for publication.

Species of Prickly Pear

Numerous varieties of cactus grow in Texas, but those that cause most trouble to livestock raisers belong to the genus Opuntia, of which there are about 30 species in the State. Only four or five of these, however, actually cause trouble to the livestock producer, and this may be attributed to some extent to their abundance and character.

The species that produce the largest plants are the Opuntia *lindheimeri* and *engelmannii.* Both these species are found well distributed over South Texas with the *engelmannii* extending westward to El Paso. It is difficult for the average individual to distinguish between the two species, as they both have large joints and often develop into large clumps. The O. *lindheimeri* species is variable in habit, being either low and wide spreading or becoming tall and treelike, sometimes with a definite cylindric trunk. It often forms thickets covering thousands of acres. The joints are green or bluish green. The O. *engelmannii* species forms a widely spreading bush, usually without a definite trunk.[1]

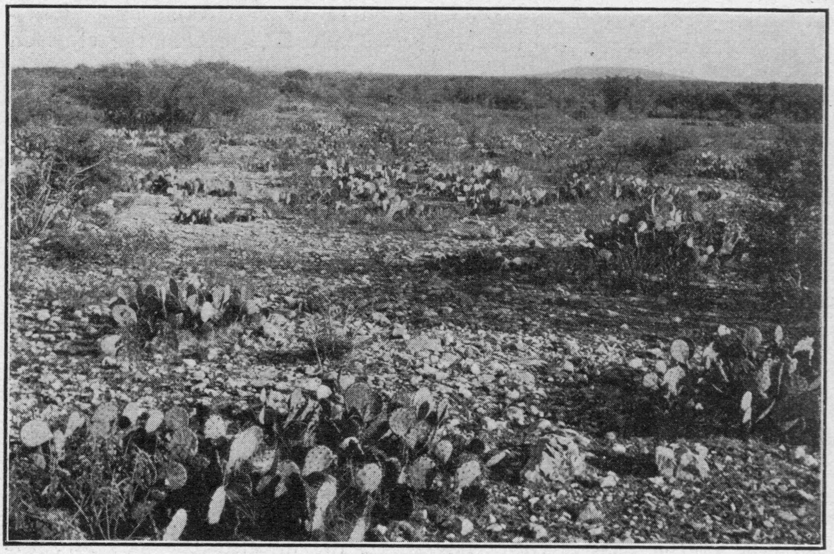

Figure 1. A typical stand of prickly pear in Southwest Texas.

Along the Gulf Coast is found the species Opuntia *stricta inermis,* which is the pest pear of New South Wales and Queensland, Australia. It is also an erect-growing type but its joints are more oblong.

Some of the low-growing, prostrate, and creeping Opuntia species are the *atrispina, tortispina,* and *polyacantha.* The first of these three species is most common in the central and southern parts of the State, while the two latter species are prevalent throughout the Panhandle and Plains sections.

[1]N. L. Britton and J. N. Rose, The Cactaceae, Vol. 1, 1919.

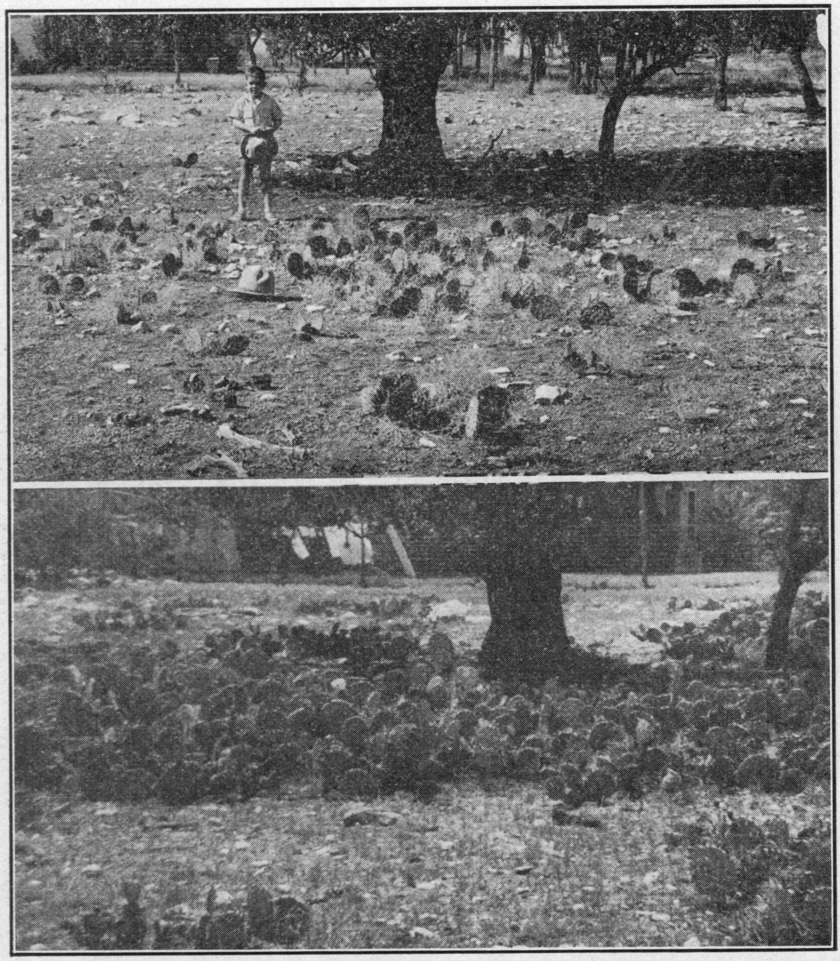

Figure 2. **The top scene shows seedling prickly pear first noticed in the spring of 1934 as it looked in November, 1934. The bottom scene shows the same group of prickly pear in April, 1939. Note that the plants are so high and thick that stock can not graze the grass growing among them.**

Spread of Prickly Pear

As a rule, prickly pear extends from the Rio Grande and the lower Gulf Coast on the south through the ranching section to New Mexico and Oklahoma on the north. It is roughly estimated that the area in Texas infested with prickly-pear comprises at least sixty million acres.

Even though species of prickly pear were described by travelers and botanists as early as 1753, it is only during recent years that the plant has become sufficiently abundant to give concern to livestock producers. One pioneer ranchman of Del Rio stated that in his early ranching days he frequently scattered joints of prickly pear over his pastures to increase the stand in order that he might have enough to singe and feed to stock during droughty periods. But in 1933 he stated that he would like to eradicate all of the plants from his pastures, because they were causing severe losses to his livestock. Another ranchman states that prickly pear has increased on his ranch about 15-fold within the past 10 years.

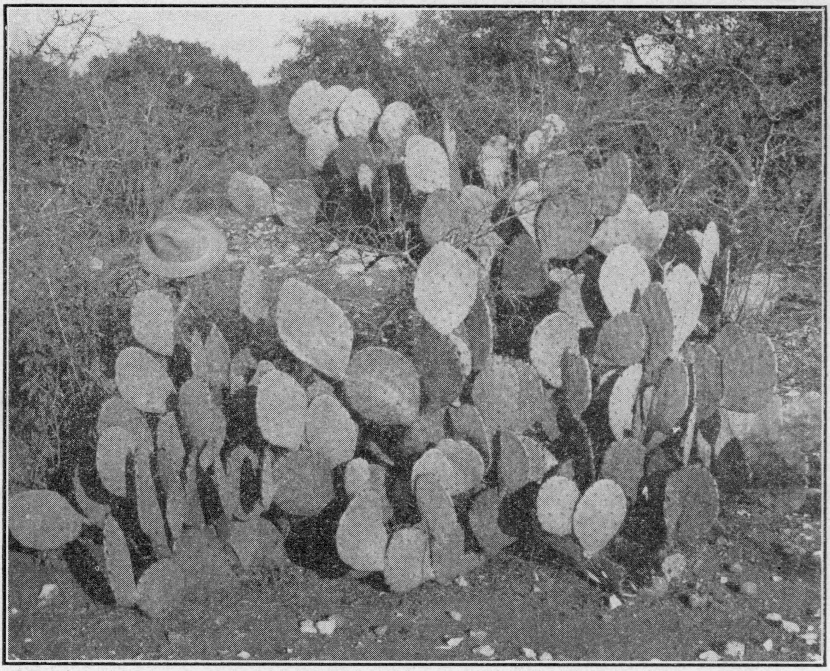

Figure 3. An average-sized prickly pear plant in the vicinity of Uvalde, Texas. Note both the height and spread of the plant. Typical of prickly pear plants that may be found scattered over a large part of Southwest Texas.

Counts made on the Ranch Experiment Station at Sonora, where prickly pear is not as abundant as in other sections, show that there are at least 33 plants to the acre. This average includes both lightly and heavily infested areas (Figure 1). In the heavily infested areas there may be as many as 1,500 individual plants or bunches of prickly pear per acre. It seems that the prickly pear has spread more rapidly in recent years, probably because of the heavy stocking of livestock following the fencing of the ranching country of West Texas.[1] The

[1]E. Mortensen, Factors in considering insect and disease control of prickly pear in Texas. Mimeographed paper.

increase of prickly pear crowds out other vegetation and occupies lands that formerly grew good grass (Figure 2). This, of course, reduces the available grazing area and, as a result, reduces the carrying capacity of the range. Figure 3 shows a typical growth of prickly pear in the vicinity of Uvalde, Texas.

By collecting and weighing, it was found that the average-sized plant on the Edwards Plateau will weigh approximately 52 pounds. There are, of course, many plants that weigh only a few pounds and others that weigh 1,000 pounds or more. Generally, the prickly pear south of the Southern Pacific Railway running from San Antonio to Del Rio grows three to four feet tall, and in some cases taller. These plants often spread so that 200 or 300 square feet of ground is covered.

Uses of Prickly Pear

Many attempts have been made to manufacture paper, alcohol, vinegar, and other commodities from the prickly pear plant, but the cost of making these products does not justify their manufacture.

The most common use of prickly pear is for stock feed. It is not known just when feeding of the plant began in Texas, but the practice was common several years before the Civil War. The early method of feeding was by cutting the plant and holding it over a brush fire to singe the spines and enable the stock to eat the plants without difficulty. In 1898 burners were developed to singe spines from the plants. These burners were patterned after the ordinary plumber's blowtorch and create a very hot flame, which singes the spines from growing plants, so that it is not necessary to cut the plants and build a fire to singe them.

In the early days it was observed that overfeeding of prickly pear produced scours and that from one to two pounds of cottonseed products fed with the pear produced much more favorable results. This led to the belief that the pear was probably high in some mineral salts that cause scours and low in feeding value, because when cottonseed were fed with it a more desirable response was produced.

Table 1 shows the feed composition of prickly pear in comparison with pasture grass and sorghum silage. It is seen from the table that silage and pasture grass have an advantage over prickly pear in every element except ash and fiber. The most pronounced difference is in protein content, which is approximately five times as great for grass as for prickly pear.

The table shows that prickly pear has a feed ratio of one part digestible crude protein to 18 parts of digestible carbohydrates and fats. A balanced ration should have a nutritive ratio between 1:5 and 1:7. This means that for cattle to get a balanced ration or full feed of prickly pear alone they would have to consume 350 to 400 pounds per head a day. Such quantities as these are beyond all reasonable expectations. In fact it has been well demonstrated that cattle should not be expected to consume more than 40 to 50 pounds of prickly pear per head per day without experiencing the ill effects of excessive scouring. If this quantity is fed with one to two pounds of cottonseed cake and old grass or browsing plants are available for cattle, they will maintain strength and fair condition throughout the winter or an ordinary drought.

Table 1. Feed composition of prickly pear compared with native grass and sorghum silage (green)*

Kind of feed	Water	Ash	Protein	Fat	Nitrogen free extract	Fiber	Organic matter
Native grass	80.00	2.00	3.50	0.80	9.70	4.00	18.00
Sorghum silage	69.10	2.60	2.10	0.80	17.50	7.90	
Prickly pear	84.26	3.06	0.73	0.34	9.04	2.41	12.53
Spineless cactus	71.42	7.25	.31	0.34	13.33	7.35	
Prickly pear fruit and buds (dry)	....	13.65	11.69	2.07	53.13	12.98	
Prickly pear fruit only (dry)	....	6.08	4.58	5.48	48.69	32.37	

*Analysis made by the Division of Chemistry.

Losses of Livestock Caused by Eating Prickly Pear

Even though ranchmen practice feeding prickly pear to their livestock during periods when there is a scarcity of natural vegetation caused by long periods of drought, the stock do not stop eating the prickly pear when the ranchmen quit singeing the spines from the plants. During the past few years it appears that sheep and cattle have started eating prickly pear more generally than they did during the previous years. It is nothing unusual to see them grazing on the plants (Figure 4) even though there is a considerable amount of grass and brush available for them. In the winter months stock will graze on plants that have not been singed and will continue eating the young buds, blooms, and apples on into the summer. Stock that eat prickly pear in this manner are affected by ulcers and sores in their mouths and on their lips and in the spring, summer, and fall screw worms infest these sore lips and cause much trouble (Figures 5 and 6).

Numerous inquiries have come to the Station from the ranching section of Texas asking for information on the eradication of prickly pear, as livestock were eating the plants and, as a result, heavy losses were being sustained.

A typical inquiry says: "My sheep are eating prickly pear and I would like to know if there is some treatment I can give them to make them stop. How can I get rid of the plants?"

Other statements are something like this: "I had 1,200 cases of screw worm in 6,000 head of sheep caused by eating prickly pear. There is a large percentage of 'dogie' lambs and many of these have died."

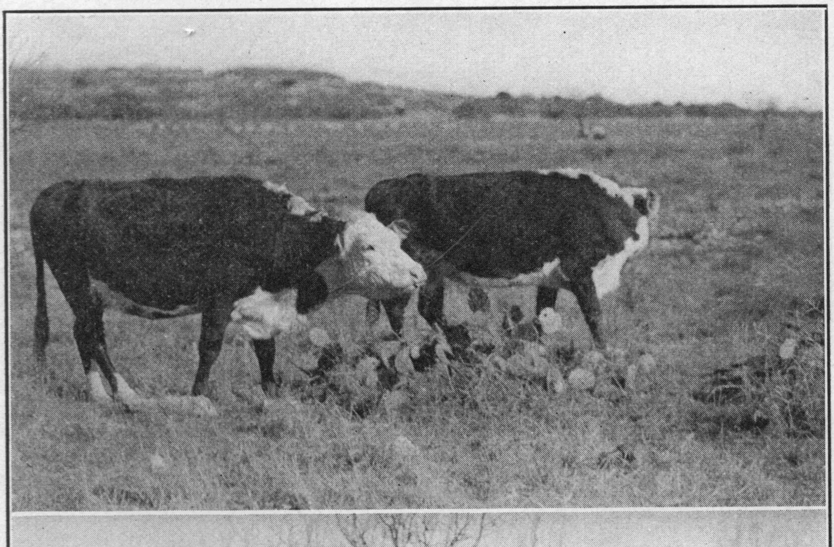

Figure 4. Cattle grazing on unsinged prickly pear above and singed prickly pear below.

Mr. J. W. Owens near Sheffield stated that in the winter of 1935 he lost about 75 ewes that had been eating singed prickly pear (Opuntia atrispina) for 45 days. The sheep, as a rule, lived two or three weeks after getting sick. Upon being posted the ewes showed an accumulation of sand or granules in the fourth stomach. This sand, or granules, is present in the base joints of the Opuntia atrispina. The sheep were taken off the prickly pear, and the trouble stopped. Figure 7 shows how sheep eat and scatter unsinged prickly pear.

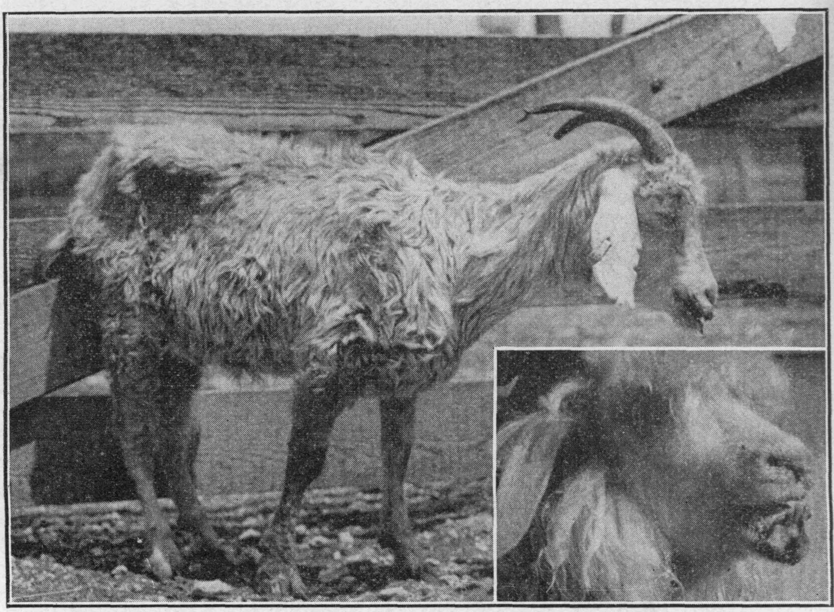

Figure 5. A goat emaciated from eating prickly pear. Note that the sore festered lips are covered with fine pear spines collected while eating prickly pear flowers and buds. The inset shows a goat's mouth badly disfigured by screw worms which infested the sores caused from eating prickly pear.

When ranchmen encounter such troubles and losses as these with no promise that the livestock will stop eating the prickly pear, they naturally turn their thoughts to methods of eradication. They realize, of course, that any method used in the eradication of prickly pear from large areas of pasture land will be expensive, but they feel that if they can cut down their losses they will gain in the end.

Eradication Practices

To eradicate prickly pear entirely in this country it is necessary either to grub and pile the plants or apply poisons. Singeing the spines and grazing gives a certain amount of control but does not eradicate the

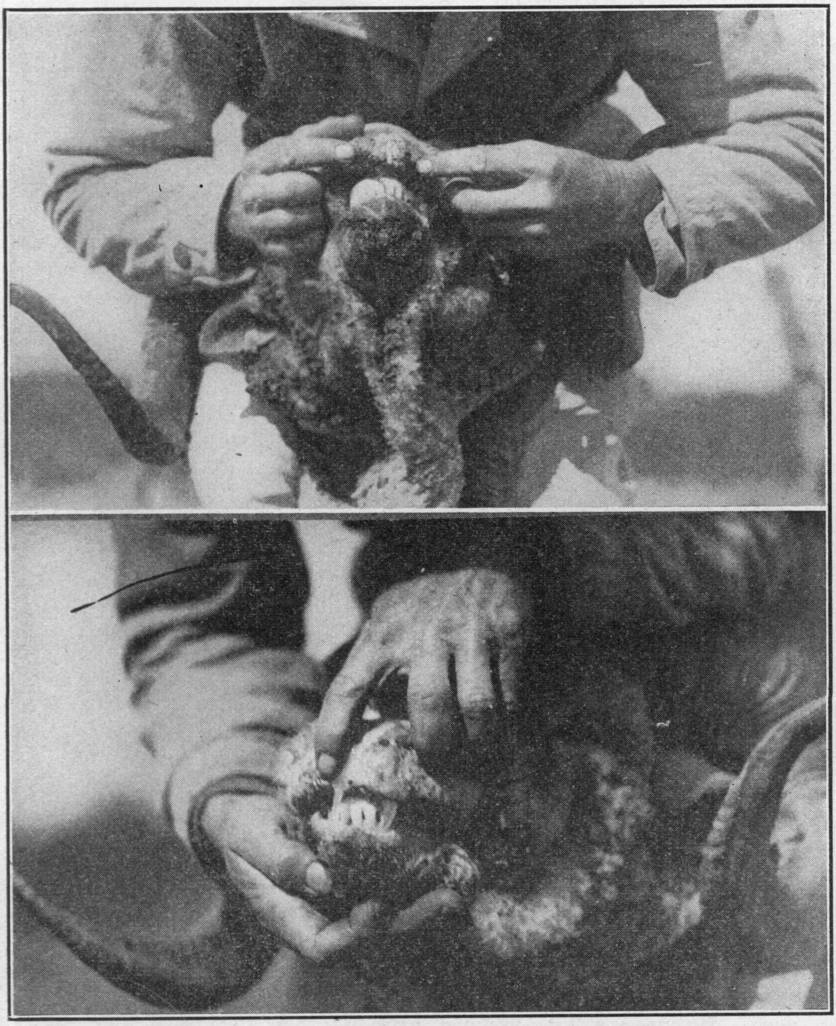

Figure 6. Sheep's mouth which is sore and irritated from eating singed prickly pear; below, the same sheep 16 days later.

plants from pastures. Insects and fungus diseases also exercise a certain amount of control, but they are not numerous enough to eradicate the plants completely. Insects are also kept in control by native parasites which hold down their numbers.

Grubbing

Many ranchmen during the past five or six years have been grubbing and piling prickly pear and in this way clearing their pastures of the plant. Judge J. A. Matthews of Albany, Texas, stated in 1934 that he had cleared 50,000 acres of his pasture lands by grubbing at a cost ranging from 25 cents to $1.50 an acre. He used a long-handled, round-pointed shovel to run under and cut up the plants, then with a pitch-

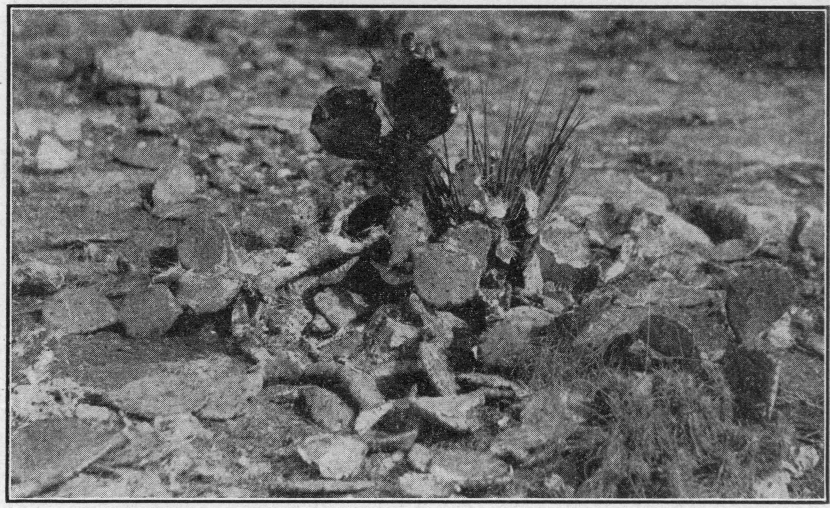

Figure 7. Showing how sheep eat and scatter unsinged prickly pear. The detached joints take root and develop into new plants. The scattering of parts of the plant is one way prickly pear is spread.

fork collected and piled the prickly pear in medium-sized piles, which were well pressed down to exclude as much air as possible.

In February 1937, V. I. Pierce of Ozona stated that he had grubbed and cleared 30 sections of rolling country at an average cost of 75 cents an acre. He used a long-handled grubbing hoe to uproot the plants and a pitchfork to throw them into small two-wheel hand carts (Figure 8) which held about 100 pounds of prickly pear. When a cart was loaded, the prickly pear was dumped into a pile with several other loads. The piles were slightly over waist high and would average about 8 to 10 feet in diameter (Figure 9). Mr. Pierce estimated that the cost of clearing was materially reduced by using hand carts. Laborers could handle these

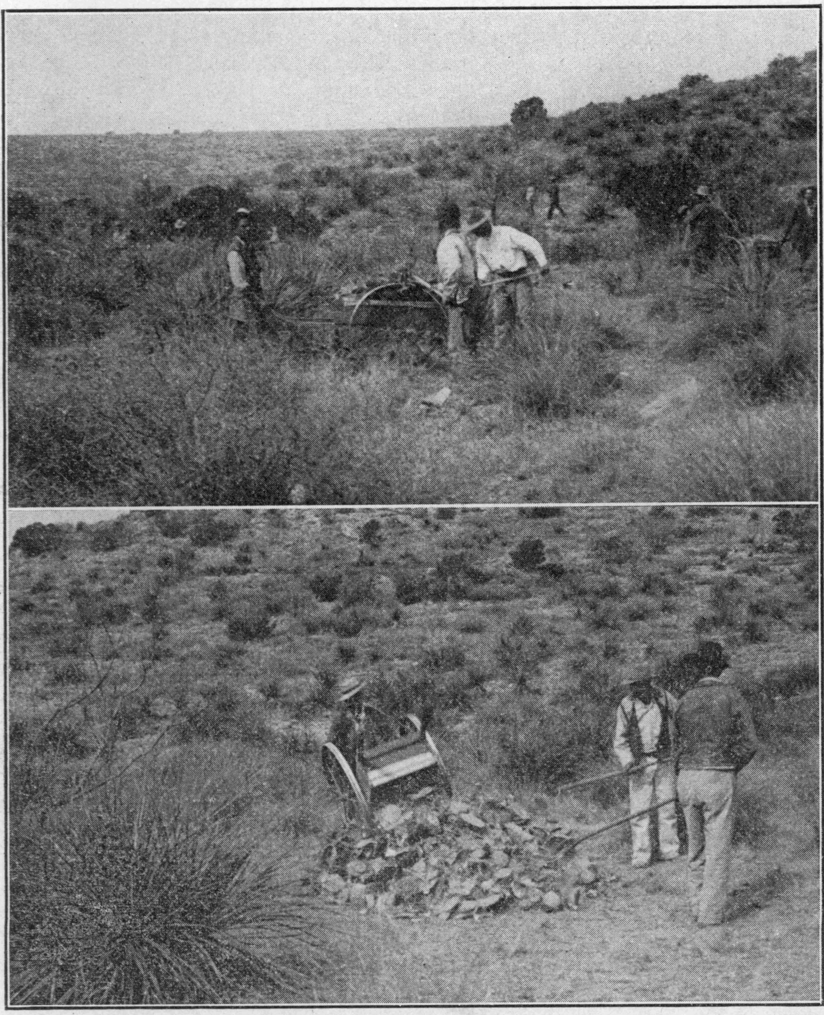

Figure 8. Pitchforks and two-wheel carts were used to handle and pile prickly pear on the Pierce Ranch near Ozona, Texas. The carts can be handled with ease on either rocky hillsides or in thick brushy valleys.

carts on rough, steep ground with comparative ease. Mr. Pierce used a 7-man crew, with 3 or 4 men grubbing, 2 men handling the carts and piling the prickly pear, and 1 following behind to collect any scattered joints or pieces that were missed by the men doing the piling.

One interesting observation made on Mr. Pierce's piled prickly pear was that where prickly pear was grubbed in March 1936 and cattle kept out of the pasture until the following November, there were no live plants (Figure 10). Except for a few scattered joints around the edges that were in contact with the ground, most of the pear had died. The cattle when turned in the pasture in November, ate all of the live

Figure 9. Typical pile of grubbed prickly pear on the Pierce Ranch near Ozona, Texas. It is necessary to have good-sized piles to kill the plants completely.

prickly pear and in this way eliminated the necessity of having a crew go back over the pasture and mound up the green plants around the edges of the piles. Mr. Pierce stated that the prickly pear in this length of time had not had time to become heavily rooted and the cattle could pull any of the rooted joints up and eat them.

He grubbed another pasture at the same time (March 1936), but the cattle were left in the pasture. A considerable number of green joints were around the piles, because the cattle had been grazing on the prickly pear during the summer months and had scattered sections, which

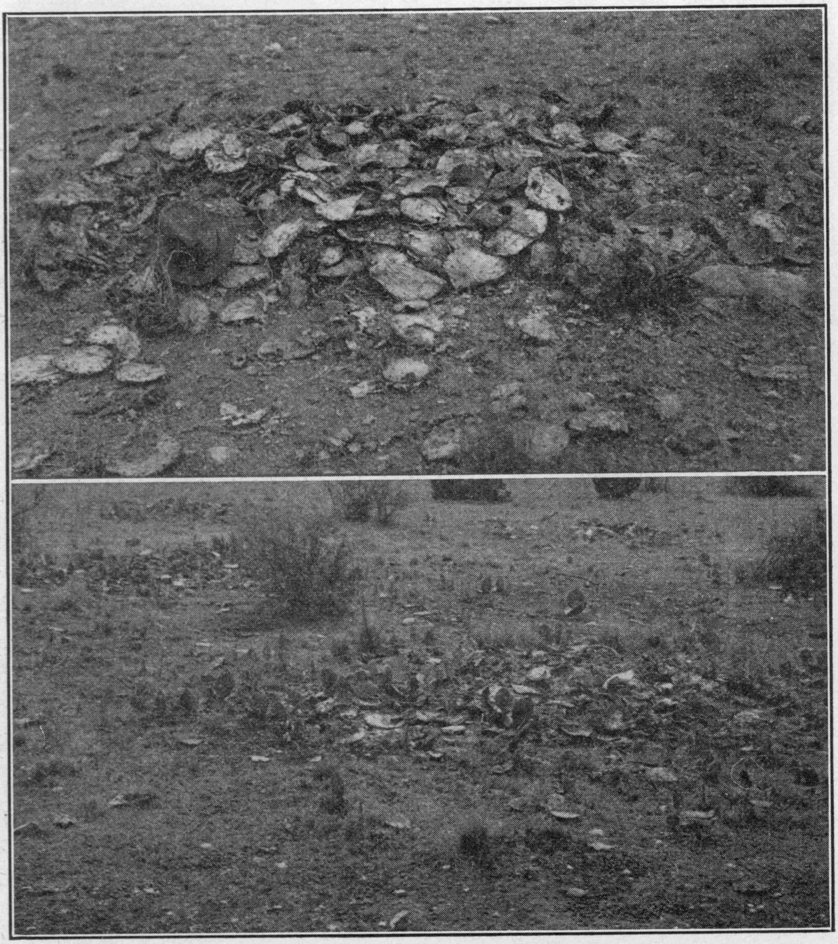

Figure 10. The top scene shows a pile of prickly pear completely dead where cattle were kept out of the pasture for six months after the plants were piled. The bottom scene shows rooted joints of prickly pear around the residue of a pile where cattle were left in the pasture after piling. Compare this wtih the condition of the prickly pear shown above where cattle were kept out of the pasture until the plants were too dry to be eaten.

had become rooted (Figure 10). It appears, therefore, that proper management of cattle in connection with grubbing of prickly pear can materially aid in cutting down any clean-up costs.

In January 1933 John Mitchell grubbed several sections of prickly pear on his ranch, which is located on the divide between Howard's Draw and the Pecos River, about 15 miles from Pandale. The plants were grubbed with grubbing hoes and loaded into a wagon with pitchforks. From 20 to 30 wagon loads were dumped in circular windrows about the pasture (Figure 11). An examination in February 1937 showed that all the plants had died and there were no green and rooted slabs around the piles (Figure 11). Mr. Mitchell estimated that the cost of grubbing and hauling the prickly pear in this way was approximately 50 cents an acre. Where the same method is used in the brushy draws where there is heavy infestation, the cost ranges from $1.25 to $3.00.

Burning and Grazing

The people who are not familiar with the prickly pear plant suggest that it can be utilized for feed and at the same time eradicated by burning the spines and letting stock eat the plants. Observations in several areas where singeing (Figure 12) and grazing were practiced indicate that most of the running type of plant is killed by this method but the variety having large, woody, and fibrous trunks is not, because the stock cannot consume the woody base (Figure 13). Where this method was practiced the prickly pear re-established itself every three or four years. Often it was more abundant after burning and grazing than before, as the stock scattered numerous joints and sections not consumed. This perhaps indicates that the amounts singed were in excess of the amounts which could or would be consumed by the livestock. Excessive amounts should not be burned.

It seems that effective eradication may be expected where prickly pear is singed or burned for cattle and the remaining stumps grubbed out. The cattle will consume the singed plants and pull up 10 to 25 per cent of the stumps. The remainder of them have to be grubbed, and grubbing requires about half as much time as burning. The cost of this method, which includes the labor to burn and grub and the gasoline (white), will be about 38 cents an acre for light infestations (2 to 9 per cent cover). By this method the prickly pear growth is utilized for livestock and the necessity of piling and later working the edges of the piles is eliminated. A good clean-up job can be accomplished if the grubbing of the stumps follows about one or two days after the burning. The system can be applied satisfactorily during the winter months and periods of drought or adverse range conditions.

During the winter of 1938, 103 acres of rough rocky pasture on the Range Experiment Station, near Sonora, was cleared of prickly pear by burning or singeing and grazing. The degree of infestation was classed as light. Gasoline costs $15.32 and labor for burning and later

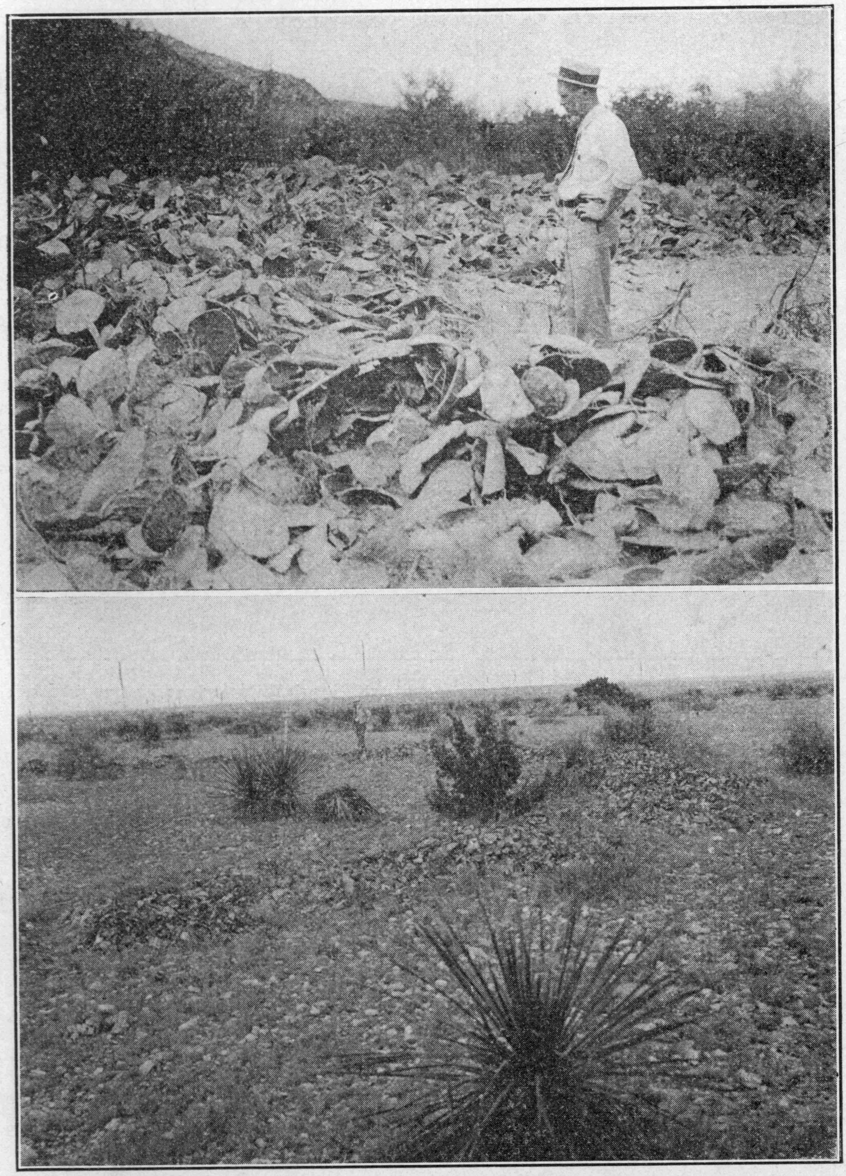

Figure 11. At the top is a pile of prickly pear on the John Mitchell Ranch near Ozona, Texas. in July 1933. It was hauled in wagons and piled into large windrows. The bottom scene shows the decayed residue of about 20 or 30 wagonloads of prickly pear four years after it was grubbed and piled. Note that there is no living prickly pear about the edges of the pile.

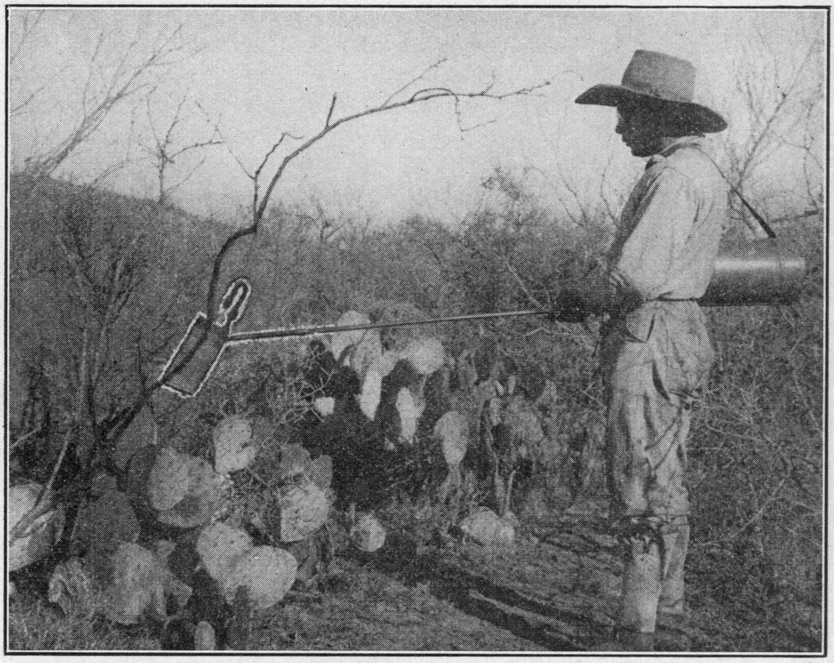

Figure 12. Burning the spines from prickly pear with a prickly pear burner. One man can singe enough plants in a day to supply feed for 150 to 260 head of cattle.

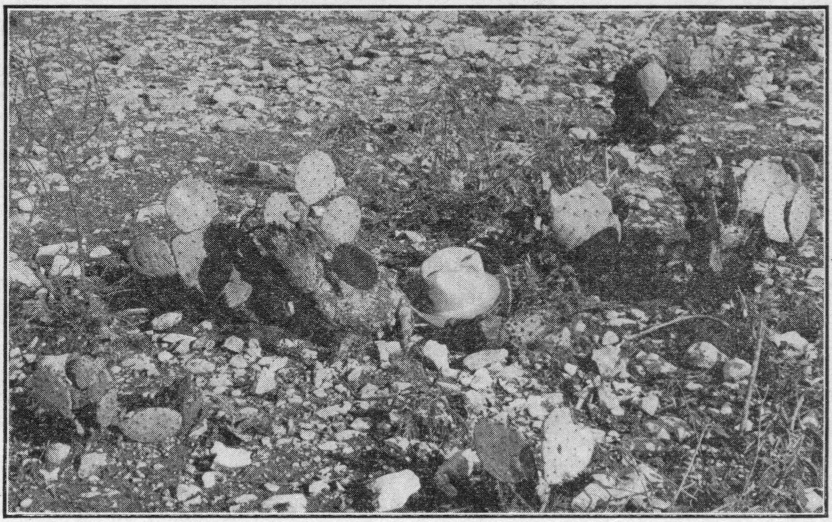

Figure 13. Showing how cattle leave the large woody trunks of prickly pear after the plants have been singed and grazed on. Note the one season's growth on the stumps.

cutting out the stumps left by cattle amounted to $23.00, making the total cost for the 103 acres $38.32, or approximately 37 cents per acre.

Observations on Sheep That Have Eaten Singed Prickly Pear

On December 11, 1934, the spines were singed from several prickly pear plants to make them edible for 39 head of Rambouillet rams. Within four days the rams were consuming the prickly pear readily. Each day a fresh supply was singed for the sheep to graze on. It appeared that the rams preferred the hot, freshly-burned prickly pear, as they followed closely behind the burner. They bit first on the terminal joints and, if they held fast, the bites were cut out and eaten. This continued until the whole plant was consumed or hard and fibrous parts were reached. If, however, the terminal joint broke off at the first bites, it was dropped to the ground and no attempt was made to eat the joint again. A number of these slabs took root and grew the following spring.

On February 2, 1935, it was noticed that the rams were becoming emaciated and drawn. They were examined and notes were made on the condition of the 39 rams. Every sheep in the pasture had sore ulcerated lips, sore gums, sore tongues, snotty noses, and mouths which were offensive to smell (Figure 6). Numerous screw-worm flies were observed about the mouths of the sheep but no screw-worm cases were found at that time.

On February 18 another examination was made of each ram's mouth. All were swollen, sore, ulcerated, and pussy, some so badly that the lips were stuck together. Screw-worm flies were lighting on the sores. It was considered advisable to put the rams in a pen to be fed hay and grain so that their mouths would heal.

These observations indicate that even though the spines were singed off with a pear burner, enough unburned spines remained to cause the mouths of the sheep to become sore and ulcerated, creating a screw-worm menace. It was also observed that even though the outside ends of the small bundles of spines were well singed or burned off, the inside ends embedded in the prickly pear slabs were almost as sharp and spiny as the outside or exposed ends. This perhaps limits the use of singed prickly pear for sheep very materially, as there is no way to burn both ends of the spines.

Insects and Diseases

It has been observed for many years that numerous insects and diseases injure prickly pear plants. Much interest in the possibility of eradicating these plants by the use of insects and diseases has been manifested in West Texas during recent years.

Insects: During the past two years several ranchmen in the vicinity of Ozona collected and liberated insects on their ranches, hoping that they would multiply sufficiently to eradicate the prickly pear as they did in Australia. In Texas, due to the numerous parasites which keep the insects that feed on prickly pear from multiplying, it cannot be expected that insects will do anything more than exercise a limited amount of control in areas where the prickly pear has become dense.

The insects feeding on prickly pear include moth borers, beetles, flies, stink bugs, scale insects, and red spiders. Mortensen states that the most important insect from the Texas standpiont is the cottony cochineal *(Dactylopius confusus)*, which sucks the juices from the plant until the infested part dies (Figure 14). Another important insect in Texas is the stink bug. The most outstanding species is the *Chelinidea vittiger*, a grayish bug about one-half inch long, the nymphs of which are of various colors, depending upon the state of development, and these feed in groups. They cause yellow spots where they have been feeding, and a characteristic of their feeding is the white limey color of their excretions.

The cactus beetle is common in Texas, and the *Moneilema* genus averages about 1 to 1½ inches long and one-half inch broad with long antennae. Their eggs, which they lay in the bases of the plants, hatch into grubs which eat the stem and roots of the plants. The beetles themselves feed on the joints and fruits of prickly pear and cause only negligible damage.

Figure 14. Cochineal, a soft-bodied scale insect sheltered beneath a white or downy secretion of fine silky threads, feeding on prickly pear on the Ranch Experiment Station. This insect has some effect on retarding the spread of prickly pear.

Of the moth borers the *Molitaro* are common in Texas. They are the most destructive of all the prickly pear insects in Texas. The cactus mite, or red spider (*Tetranychus opuntiae*), spins a light protective web and feeds in groups. The prickly pear forms a corky tan or light-brown tissue as a result of its feeding, and this gradually spreads until the "pores" of the plant close and "choke" it to death. Heavy rains are destructive to the mite, and it is seldom harmful except in dry winters.

Many other insects affect the prickly pear plant, but do little damage.

Diseases: The prickly pear is subject to fungus diseases, the most destructive of which is the anthracnose, or shot hole, disease (*Gleosporium* *lunatum*). With fairly humid conditions in the spring this fungus causes extensive destruction to young prickly pear growth. It often enters the plant through holes from which the cactus midge *(Asphondylia opuntiae)* has emerged, or it may gain a hold through abrasions on the joints. It is also carried by the cactus stink bugs from plant to plant and can take hold where conditions favor. Two other diseases are sun scald and black mold.

Poisons

Work in Australia: The first official step on record to eradicate prickly pear in Australia was the appointment in 1911 by the Minister of Lands (Hon. E. H. Macartney) of a scientific board to advise the Government as to the best means to adopt for eradicating the prickly pear pest by chemical or biological agencies.[1] On the recommendations of this board the Australian Prickly Pear Experiment Station at Dulacca, Queensland, was established in 1912 to investigate chemical means of prickly pear destruction. During a period of four years Dr. Jean White and his assistants conducted about 10,000 experiments. Every reasonably priced chemical substance was tested in a great number of different combinations.

In 1916 Dr. White announced as a result of these experiments: "For poisoning prickly pear by either injection or spray methods these is no doubt that arsenic pentoxide (As_2O_5) is superior to all other chemical specifics."[2]

At that time the World War was in progress and nothing definite was done until the Royal Commission on Prickly Pear in 1923 drew attention to arsenic pentoxide as a proven prickly pear destroyer of unique value. As a result, the Prickly Pear Land Act of 1923 was passed and the Prickly Pear Land Commission was appointed and assumed office April 14, 1924. In May 1924 this commission ordered one hundred tons of arsenic pentoxide, and another order for two hundred tons was placed in January 1925. This poison was distributed to landholders at cost. The commission provided suitable apparatus for applying arsenic pentoxide by arranging with Mr. W. D. Sanderson of Brynestown to manufacture stabbers and Mr. C. E. Propert of Sydney to manufacture atomizers. During the first year 568 atomizers and 1,075 stabbers were sold at cost by the commission. After functioning for eight years, the Prickly Pear Land Commission in its last report in 1932 stated that in 1923 prickly pear was spreading at the rate of 800,000 acres per annum, land was going out of occupation, and the plight of many settlers was desperate.[3] In 1932, however, by the use of poisons and insects, 1,141,458 acres of land formerly densely infested and held as prickly pear leases had been made available to 1,165 settlers with the agreement that development be continued and 725,667 acres of land once heavily infested had been

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[1]First Annual Report of the Prickly Pear Land Commission, Queensland, June 1925.

[2]Arsenic pentoxide (As_2O_5) is in the pure state a dry white powder. It is produced by the oxidizing of ordinary arsenic with nitric acid, by heating to a red heat. In the liquid state it is termed arsenic acid.

[3]Eighth Annual Report of the Prickly Pear Commission, Queensland, June 1932.

reselected by 95 persons as development grazing land. Since the Prickly Pear Commission went out of office in 1932 the work has been carried on by the Land Commission with continued success.

Work in Texas: For several years prior to 1933 many inquiries were received from ranchmen asking how prickly pear could be controlled or eradicated. Because of this widespread concern of ranchmen and the keen interest manifested by the Sheep and Goat Raisers Association, experimental work was started by the Experiment Station in 1933. Because of the great distance between Texas and Australia, the differences in climate, and the existence of numerous species of prickly pear in Texas that were not prevalent in Australia, it was not known whether or not similar results could be obtained in Texas with arsenic pentoxide. The experiments begun in January 1933, therefore, not only involved the testing of numerous poisons but also the development of equipment for applying the poisons. About 1929 Judge J. A. Matthews of Albany, Texas, imported a stabber from Australia with the idea of applying arsenic pentoxide poison to prickly pear plants. He tried to get several men interested in contracting to use the stabber with a guarantee that the plants would be entirely eradicated, but no one would undertake the job under those terms. As a result, no work was done with this stabber. In 1933 the stabber could not be located, and an attempt was made to design and construct a stabber that would inject poison into prickly pear plants.

Methods and Scope of Experiments

In outlining the experiments to be conducted, several objectives were listed, and these are given below:

(1) To test various chemical poisons to determine a formula that would be effective in killing prickly pear.
  - (a) When injected into the plants by means of a stabber.
  - (b) When sprayed on the plants by means of an atomizing sprayer.

(2) To determine the effect of chemical poisons when applied at different seasons of the year.

A successful prickly pear poison should possess the following requirements as set forth by the Australian Prickly Pear Commission:[1]

(1) "Cheapness in material and economy in quantities required.

(2) "Capacity to circulate freely through the pear plant and penetrate the extremities of the roots, thereby destroying all life in the plant.

(3) "Reasonable sureness in giving effective results.

(4) "Ease and safety in handling and economy of labor and time in application."

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[1]First Annual Report of the Australian Prickly Pear Commission, Queensland, June 1925.

Because the Ranch Experiment Station near Sonora is located in the area infested with prickly pear where much trouble is caused by livestock's eating the plant, the experiments were conducted at that station.

A small amount of work was done on the W. C. Bryson ranch near Uvalde, as the prickly pear on this ranch was much larger than that at Sonora. Observations were made of the work done by several ranchmen who applied a poison purchased from a commercial concern.

Poisons Used

The principal poison used throughout the experiments was arsenic pentoxide. It was used, however, in several different strengths and combinations, with and without commercial strength sulphuric acid. Other poisons used included calcium chlorate put out under the trade name "Atlacide," sodium arsenite, ammonium sulfocyanate, a special arsenic acid, arsenic trioxide or white arsenic, crude oil, and kerosene.

Equipment

Stabbers: As the stabber imported from Australia by Judge Mattews could not be located, it was necessary to design and construct one before any poisons could be injected into the prickly pear plants. The first stabber developed is shown in Figure 15. Briefly, the stabber consisted of a brass pipe about 1½ inches in diameter and approximately 4 feet long. On the lower end a curved blade was attached to the side of the pipe to cut holes in the plants. On the inside of the pipe and adjacent to the blade was a small cylinder fitted with a plunger rod to draw in and eject the liquid. The liquid poison was drawn in through the ball valve on the side of the cylinder and ejected through the needle valve, at the lower end, onto the blade and into the plant. The plunger rod extended through the pipe and had a handle on the upper end so that a slight tap on the rod would force the charge out through the needle valve. The arsenic pentoxide solution was so highly acid that this stabber proved impractical.

Another stabber developed consisted of a pipe closed at the bottom except for a small hole through which the liquid poison flowed when a cap was lifted by a hinged handle connected from the upper end (Figure 16).

Sprayers: The first sprayer used was a small, portable, compressed air garden sprayer having a working pressure of about 65 pounds. The spray put out was too watery and wasteful. As no suitable high-pressure sprayer could be obtained from manufacturers in the United States, a special atomizer for use in eradicating prickly pear was imported from Australia (Figure 17). This atomizer was designed to stand a working pressure of 120 pounds. The high pressure forced the liquid poison out through a small pinhole nozzle and broke it up into a fine, foglike mist sufficient to dampen a prickly pear plant. A sprayer of this type is

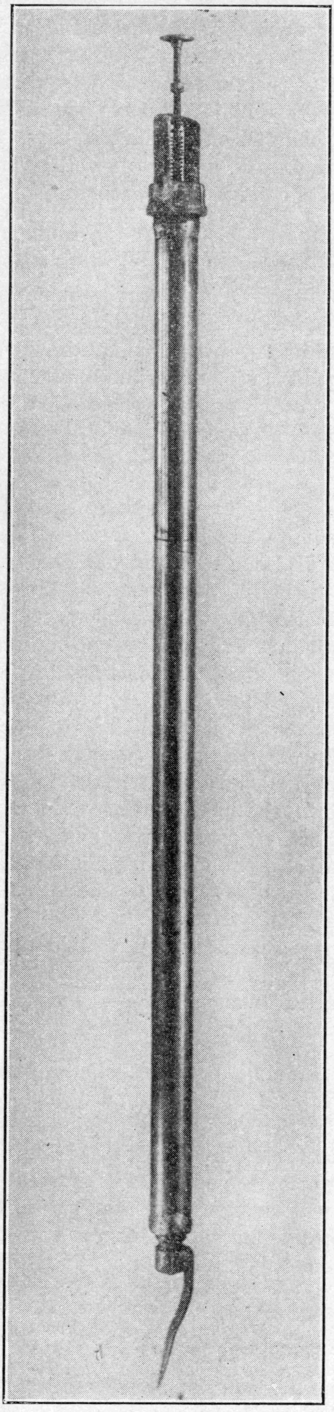

Figure 15. An experimental injector type of prickly pear stabber.

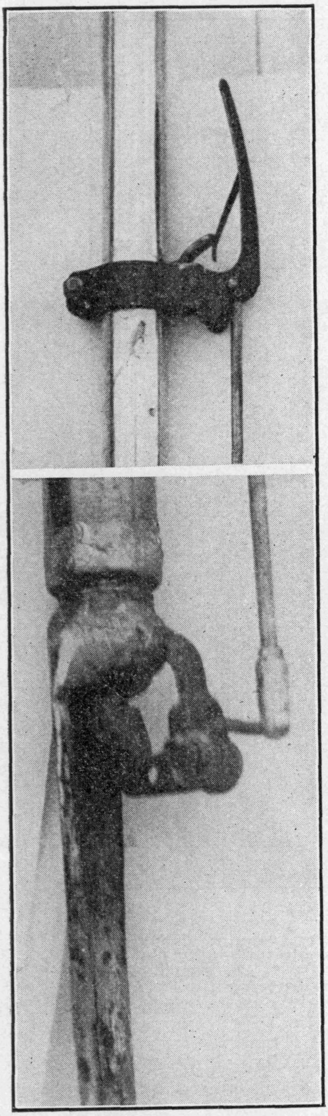

Figure 16. Gravity type experimental prickly pear stabber. By pressing down on the lever shown at the top, the rod, by means of a rocker arm, lifts the cap from the nozzle, thus permitting poison to flow down the blade shown at the bottom.

economical with spray materials and, if carefully handled, will put out enough poison to be effective on the plants and not kill an excessive amount of grass growing around them. This atomizer was used in all experiments from September 1933 on, and it is still in good condition.

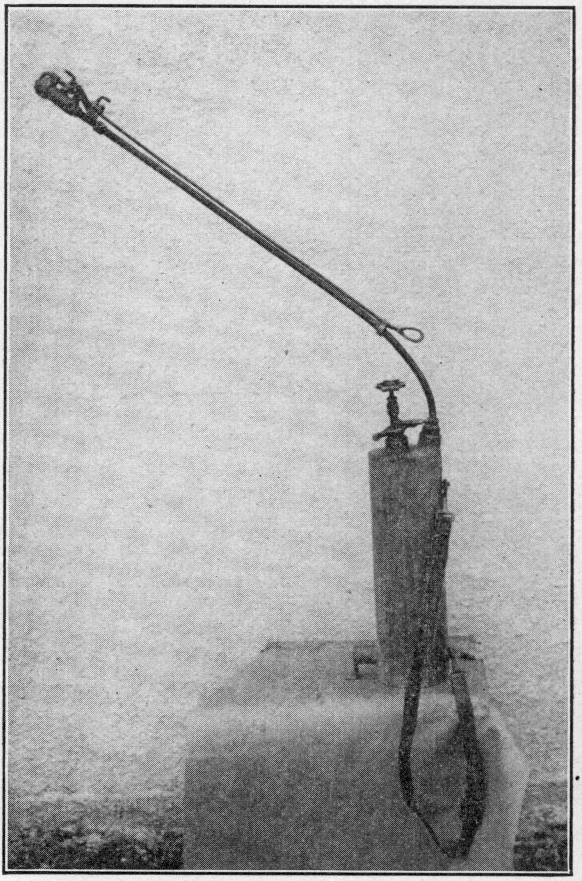

Figure 17. The Australian prickly pear atomizer. About three-fourths of a gallon to one gallon of poison was poured into the tank and after the filler cap was screwed on tightly, from 110 to 120 pounds of air pressure was placed in the remaining space. This high pressure aided in breaking up the liquid into a fog-like mist.

Procedure

In the beginning an effort was made to determine whether the poisons applied would affect spineless pear (O. *ellisianna*) and prickly pear in the same manner. Three strengths of straight arsenic pentoxide were prepared, consisting of 1, 2, and 3 pounds of arsenic pentoxide to 1 gallon of water. These were applied by stabbing the plants one, two, and three times to determine the best strength and quantity of poison most effective. As the Station had an 8-acre field of spineless pear (Figure 18) and pastures infested with prickly pear, 30 plants were stabbed one time, 30 two times, and 30 three times with each of the three solutions of arsenic pentoxide and a saturated solution of calcium chlorate. This was done on both spineless and prickly pear.

A solution consisting of 80 per cent sulphuric acid and 20 per cent arsenic pentoxide was sprayed on both spineless and prickly pear in both concentrated form and diluted 50 per cent with water. A small portable compressed air sprayer was used to spray the solutions on the plants.

Results obtained when the plants were stabbed only one, two, or three times were not effective, and in all tests conducted afterward the plants were stabbed at the base, at the junction of branches, and at as many

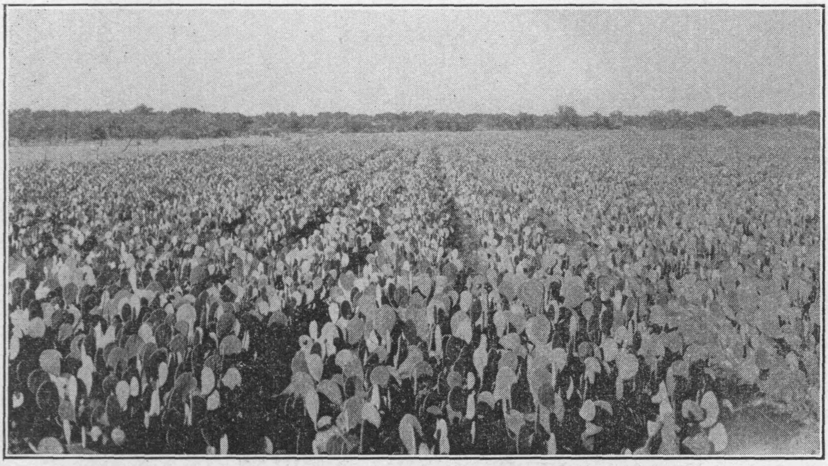

Figure 18. Field of spineless prickly pear (Opuntia ellisianna) at the Ranch Experiment Station near Sonora. This provides succulent feed for livestock during droughty periods without the injurious effects of spines.

other points as it appeared necessary to kill the plant thoroughly. The amount of material and the time required to treat a certain number of plants were carefully recorded, so that the costs might be calculated.

In September 1933 the Australian prickly pear atomizer was used for the first time. One-half gallon of a solution was measured into the tank and the air pressure brought up to 110 pounds. The plants were sprayed until all of the material had been used. The time required was recorded, the number of plants sprayed counted, and the area measured and mapped.

This procedure was followed throughout the series of tests. Tests were conducted during the different seasons of the year to determine seasonal influence on the effectiveness of the poisons.

A portable air compressor, equipped with a two-cycle gas engine and tank, was purchased. This was placed in a truck and transported to the pasture where the spraying was being done (Figure 19). Considerable time and labor were saved by the use of this equipment, as the required air pressure could be placed in the sprayer tank in a few seconds, whereas it took several minutes of hard labor to get the required air presuure with a hand pump.

Figure 19. Equipment and chemicals used in the prickly pear experiments. Note the air compressor in the truck and method of injecting air into the atomizer tank. The stabbers are leaning against the truck and the poisons are lined up according to strength on the ground.

EXPERIMENTAL RESULTS

Stabbing

Preliminary tests: As mentioned in the discussion of procedure, the first stabbling tests were conducted in January 1933, on both spineless and prickly pear. Other tests on spineless and prickly pear were made in April and July 1933. Results of these tests showed that the spineless pear was more susceptible to the effects of poisons than the prickly pear. Because the spineless pear was grown for feed and any data obtained by poisoning it would not be applicable to prickly pear, the tests on spineless pear were discontinued.

Not enough of the prickly pear stabbed in January 1933 was killed to consider any of the tests satisfactory. Plants stabbed three times with the strongest solution of arsenic pentoxide (3 pounds to 1 gallon of water were not killed, except for a few of the smallest ones. When this area was inspected in February 1937 more plants appeared to be present than before the poison was applied. On some of the plants that were treated the center and base roots were killed, permitting the end joints to fall on the ground and take root. In many cases where this had occurred, as many as a dozen large-sized joints had grown from the rooted joints. Consequently, there are now several plants where formerly only one grew.

Tests conducted in April 1933: The stabbing tests conducted in April were similar to the January tests. Arsenic pentoxide solutions consisting of 1, 2, and 3 pounds to 1 gallon of water were used. A solution of 5½ pounds of calcium chlorate to 1 gallon of water was also used. Instead of being stabbed one, two, or three times, the plants were stabbed at the base and each branch or runner was given one or two stabs. An examination of the plants in June 1934 showed no entirely dead plants where the solution of one pound of arsenic pentoxide was used and only a few where the two and three-pound solutions were applied. The partly killed plants had re-established themselves from the roots, runners, and terminal joints. Where calcium chlorate solution was used, the only visible effects of the poison were a few partially dead joints and some joints discolored brown or reddish.

Tests conducted in July 1933: The same solutions of arsenic pentoxide and calcium chlorate used in January and April were again used, with the addition of a solution consisting of 3½ pounds of arsenic pentoxide to 1 gallon of water and one consisting of 3 pounds of arsenic trioxide dissolved in 1 gallon of water.

Such poor results had been obtained where plants were stabbed a limited number of times that it was considered best to stab them at the base, on the main branches or runners, and in as many other places as necessary to distribute the poison throughly throughout the plant into the extreme end joints. Table 2 shows that for the first solution, or 1 pound of arsenic pentoxide to 1 gallon of water, 15 plants were punctured in 252 different places. Where the 3½ pounds of arsenic pentoxide were used on 28 plants, they were given 350 stabs.

The data in Table 2 show that the total number of dead plants out of the original number stabbed averages only approximately 50 per cent, but actually when the amount of dead material is considered for all the plants the percentage of dead plant residue averages above 90 per cent. Attention is called to the fact that on the plants having 1 to 2, 3 to 4, and 5 or more joints partly alive, these joints in most cases had only a small segment that was still green. An inspection of this area in February 1937 showed that most of the living segments noted in June 1934 had died. It appeared that practically all the live plants in the area were those that were missed and had not been stabbed.

The fact that some of the plants were missed was not due to carelessness in stabbing but to the growth of several plants having separate root systems in a single bunch or clump. Under such conditions it is almost impossible to tell when a set of joints, branches, or runners are attached and growing from the same root system. When a plant having only one root system is given several injections of poison, it will

Table 2. Effects of injecting poison into prickly pear plants with a stabber—July 14, 1933

Kind of poison	No. of plants stabbed	Time required in minutes	Part of acre	c.c. of poison used	No. of stabs	June 20, 1934: Totally dead plants		June 20, 1934: Plants with joints partly alive*			No. of plants missed and not stabbed†
						Number	Per cent	1–2 joints	3–4 joints	5 or more joints	
1 lb. arsenic pentoxide to 1 gal. water..	15	14	1/18.8	251	252	5	33	3	2	5	5
2 lbs. arsenic pentoxide to 1 gal. water.	22	20	1/12.2	550	290	10	45	4	4	4	3
3 lbs. arsenic pentoxide to 1 gal. water.	40	17	1/14.6	680	384	25	62	7	4	4	9
3½ lbs. arsenic pentoxide to 1 gal.water	28	14	1/16.5	570	350	12	43	11	3	2	9
5½ lbs. atlacide to 1 gal. water.......	4	3½	1/93.6	200	....	0	0	0	0	4	0
Arsenic trioxide (white arsenic).......	20	10	1/18.3	200	175	0	0	0	0	20	0

*These joints in most cases had only a small segment green and rooted. Many died later.
†Plants missed and not stabbed were small plants among larger ones.

be killed, but, of course, a plant having a separate root system growing intermingled in a clump and not injected with poison will not be affected. It was mainly for this reason that stabbing was latter abandoned as an impractical and uneconomical method of eradicating prickly pear in Texas.

Table 2 shows that plants injected with calcium chlorate were not killed. The only part of the plant affected was a small area adjacent to the place where the poison was injected (Figure 20). Neither winter, spring, nor summer injections materially affected prickly pear, and calcium chlorate was discarded as unsuitable for poisoning the plant.

The results also showed that a solution of 1 pound of arsenic pentoxide to 1 gallon of water was too weak to give satisfactory results, and this solution was discarded. As the arsenic trioxide did not materially affect the plants, it was not used again.

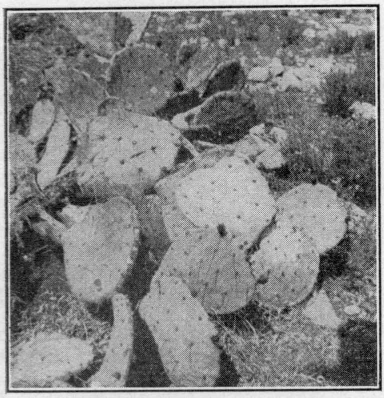

Figure 20. Showing how stabbing prickly pear with calcium chlorate (Atlacide) affected the plants. The lighter-colored areas on some of the joints are the only parts affected.

Other stabbing tests: Four more series of stabbing tests were conducted in September 1933 and February, June, and October 1934. The results obtained in all these tests substantiated the conclusion that injecting poisons into prickly pear plants by means of stabbers was not an economical practice, as many plants were not entirely killed and a large number of plants were missed and not injected, making it necessary to go over a pasture two or more times to destroy all the plants.

In all these tests the arsenic pentoxide solutions gave the most satisfactory results. The injection of crude oil and kerosene did not affect prickly pear enough to be noticeable. Sodium arsenite killed a few plants, but the percentage was not high enough for this chemical to compete with arsenic pentoxide.

Work at the Bryson Ranch: Prickly pear in the vicinity of Uvalde grows, on the average, much larger than at the Ranch Experiment Station near Sonora. Plants often produce trunks three or four inches thick and are covered with a scaly, fibrous bark. The sizes of plants range from two or three joints of ordinary size to large treelike plants as tall as the average man. (Figure 3.)

Plants of this type were stabbed in January 1933, one, two, and three times and arsenic pentoxide solutions injected. Best results were obtained with a solution of 3 pounds of arsenic pentoxide to 1 gallon of water when 1 to 2 c.c. were injected into the plant at each of the three points stabbed. Several plants were completely destroyed but the percentage was not high enough to be satisfactory.

Poisons injected by stabbing the plants several times in April 1933 gave better results than those obtained in January when not more than three stabs were made per plant. The best results at the Bryson Ranch by stabbing prickly pear and injecting poisons were obtained in July 1933. At this time the plants were stabbed promiscuously and enough times to inject sufficient poison to destroy completely most of the plants treated. Some root systems, however, were not entirely killed. Poisons injected into a branch about three or four joints from the end would cause it to collapse in three or four days. The action of the poison was so rapid at the point of injection that often the heavy joints forming the ends of the branches broke off and fell to the ground before sufficient poison had had time to reach the end joints to kill them.

Because of the inconvenience due to distance from the Ranch Station, work at the Bryson Ranch was abandoned.

Spraying

Dr. Jean White of Australia found that arsenic pentoxide dissolved in water and sprayed on young prickly pear plants penetrated and killed them, but spraying of tough old plants covered with a thick external layer of fibrous bark that the poison could not penetrate gave unsatisfactory results.[1]

Demonstration of the Roberts poison: In 1918 Mr. O. C. Roberts obtained Letters of Patent for a formula containing 20 per cent arsenic pentoxide and 80 per cent diluted sulphuric acid. When this poison was sprayed on the prickly pear, the sulphuric acid burned through the thick skin and permitted the arsenic pentoxide to penetrate into the plant tissues. Manufacture of this poison was begun by O. C. Roberts, Ltd., at Wallangarra, Australia, in January 1923.

Representatives of this company came to Texas in August 1932 and demonstrated the use of the Roberts poison on the Ralph Watson Ranch near Ozona. An attempt was made to contract with several ranchmen to spray prickly pear on their ranches, but an agreement could not be reached on the contract price per acre.

Figure 21 shows prickly pear on July 16, 1933, approximately one year after it was sprayed with the Roberts poison. At this time it was estimated that 75 per cent of the plants were dead, but most of them had either the roots and base or a number of terminal joints with enough life in

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[2]First Annual Report of the Australian Prickly Pear Commission, Queensland, June 1925.

them to re-establish themselves. Prickly pear plants weakened by the absorption of arsenic will continue to die for two or three years after the application of the poison. The effectiveness of the poison was no doubt greatly reduced by a light shower of rain which fell about 12 hours after it was applied.

Even though rain may have reduced the effectiveness of the Roberts poison when applied to prickly pear plants in Texas, the results indicated that a stronger arsenic pentoxide solution would be necessary in Texas than in Australia to obtain satisfactory results. Consequently solutions used in the tests included both weak and strong solutions of arsenic pentoxide to which different amounts of sulphuric acid were added.

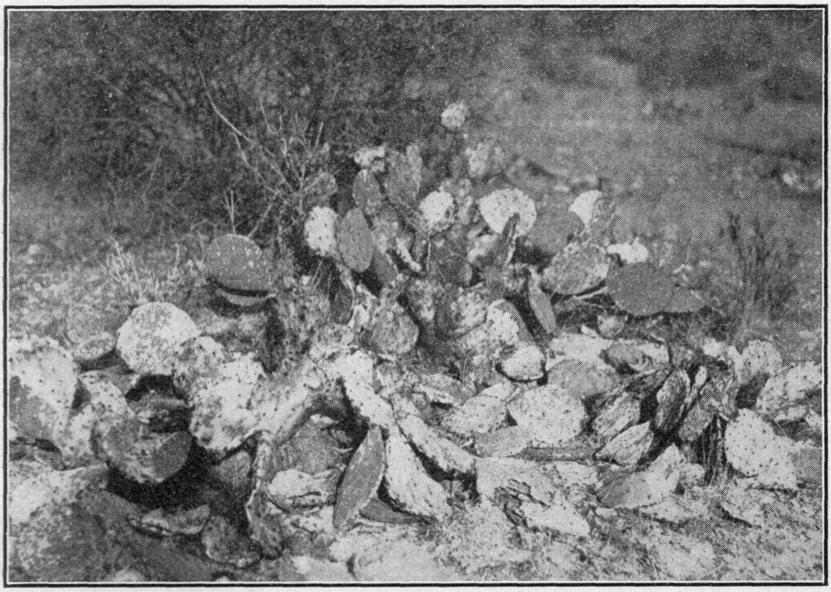

Figure 21. Prickly pear sprayed with Roberts' poison in August 1932. Not all of the plants were killed, as a light shower of rain fell within 12 hours after the poison was applied.

Preliminary spraying tests: The first spraying tests were conducted on both spineless and prickly pear in January 1933. The solution used consisted of 80 per cent commercial strength sulphuric acid and 20 per cent arsenic pentoxide by volume. Some of this poison was applied full strength and some was diluted with water 50 per cent and applied.

Results with the concentrated and diluted solutions indicated that there was not enough arsenic pentoxide to destroy completely either the spineless or the prickly pear. The acid was so strong that it seemed to sear the plants and probably prevented the penetration of the arsenic. This may have been caused to some extent by the heavy application in a watery spray and the fact that the terminal joints of the runners were not given enough attention. Another factor was the season of the year, as later results showed that poison applied in winter months did not act as rapidly and the plants were not killed so completely.

In April 1933 two solutions were made up and sprayed on both spineless and prickly pear with a small compressed air sprayer using 60 pounds of air pressure. One solution consisted of 25 per cent sulphuric acid and 75 per cent water in which 20 per cent (by weight) arsenic pentoxide was dissolved. The other was 50 per cent sulphuric acid and 50 per cent water in which 20 per cent (by weight) arsenic pentoxide was dissolved. Both of these solutions killed practically all the spineless pear plants treated but only about half of the prickly pear plants were completely destroyed. An inspection in June 1934 showed that many prickly pear plants had re-established themselves from the root systems, runners, and terminal joints.

Better results were obtained in these tests than in those in January, yet they were not satisfactory. Factors that may have influenced the results are: season, type of equipment, condition of plants, thoroughness of application, and strength of the poison.

A saturated solution of calcium chlorate (Atlacide) sprayed on prickly pear plants merely caused them to turn slightly reddish in color. No part of any of the treated plants was killed.

As in the case of stabbing, the spineless pear was more susceptible to poisons. When the same poison was applied on both spineless and prickly pear, it affected the spineless more rapidly and killed the plants more completely. For this reason the application of poisons on the spineless pear was discontinued and all tests from that time forward were confined to the destruction of the prickly pear plants.

Tests conducted in September 1933: No prickly pear was sprayed at the time the stabbing tests were conducted in July 1933 because of the poor results obtained with the low-pressure sprayer and the desire to wait for the arrival of the special atomizer from Australia. The atomizer was received on September 1, 1933, and it was used at the Ranch Experiment Station on September 5 to spray several solutions on prickly pear (Figure 22).

The data in Table 3 show the various poisons used and the high percentage of totally dead plants obtained with three solutions. One solution consisted of arsenic pentoxide only, one of arsenic pentoxide to which was added 25 per cent (by volume) of sulphuric acid, and one of an undiluted commercial arsenic acid (arsenic pentoxide) solution.

In June 1934 only an occasional joint was not entirely dead. The parts still green consisted largely of small segments along the edges of joints that probably were either rooted or in contact with the ground at the time of spraying. When an inspection of these areas was made in February 1937, approximately 3½ years later, none of the sprayed plants were found alive. The dead prickly pear was fairly well rotted; especially if it had thick, large, succulent joints at the time it was sprayed. The

Table 3. Effects of spraying poisons on prickly pear plants with an atomizer—September 5, 1933

Kind of poison	No. of plants sprayed	Time required in minutes	Part of acre	c.c. of poison used	June 20, 1934				
					Totally dead plants		Plants with joints partly alive*		
					Number	Per cent	1–2 joints	3–4 joints	5 or more joints
3 lbs. arsenic pentoxide to 1 gal. water........	23	15	1/4.4	1000	20	87	2	1	0
3 lbs. arsenic pentoxide to 1 gal. water and 15% sulphuric acid (by volume)...........	100	25	1/2.2	1900	81	74	15	8	5
3 lbs. arsenic pentoxide to 1 gal. water and 25% sulphuric acid (by volume)...........	105	25	1/2.4	1900	91	87	7	6	1
20% arsenic pentoxide, 15% sulphuric acid, to 1 gal. water..........................	130	23	1/1.9	1900	95	73	21	9	5
20% arsenic pentoxide, 25% sulphuric acid, to 1 gal. water........................	80	20	1/1.7	1900	43	54	20	13	4
Arsenic acid (undiluted)..................	37	15	1/5.2	....	33	89	2	2	0
Sodium arsenite (diluted)................	....	....	....	....	0	0	....	....	....
Kerosene......................................	....	....	....	....	0	0	....	....	....

*Mostly segments of terminal joints, rooted runners, or young sprouts.

low-growing runner type with thin, small joints was still not well decayed. Many of the dead joints were intact with stiff spines on them. They crumbled readily, however, when stepped on. It was observed that where a large plant had been sprayed, in most cases, no grass was found growing in the area originally covered. Where some plants were sprayed too heavily there was no grass nearer than 8 to 12 inches from the dead prickly pear. Wherever a mass of the dead, spiny prickly pear remained, stock appeared to avoid grazing nearer than 6 inches to it. In other words, there was a ring of tall, ungrazed grass around the dead but undecayed plants. Some bunch grass was growing among the dead plants. Where the plants sprayed were small, mesquite or buffalo grass had sent runners out over the dead prickly pear but they were held high enough to prevent roots from the nodes reaching the ground.

A few scattered seedlings were found, which fact indicates that some

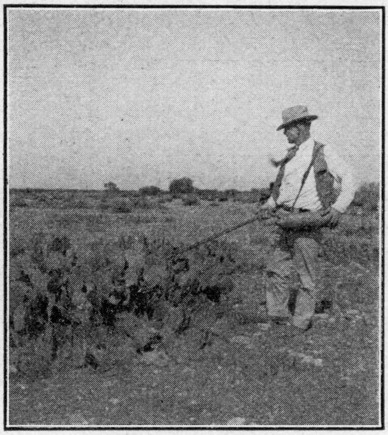

Figure 22. Spraying prickly pear with the Australian prickly pear atomizer. The plants should be given a light application from both sides, and the poison should adhere to the plants like a heavy dew. Applying poison in quantities so that it will drip from the plant is wasteful. Arsenic will remain in the soil until leached out by rains—a process which may require many months or even years.

clean-up work must be done every two or three years to keep a pasture free of prickly pear.

Tests conducted in January 1934: Practically the same solutions were used in January 1934 as in September 1933. The results obtained, however, were materially different. When the areas sprayed were inspected in June 1934, five months after they were sprayed, no plants were found that were 100 per cent dead except where a commercial arsenic acid, diluted 50 per cent, and a solution of 3 pounds of arsenic trixide to 1 gallon of water were used. The arsenic trioxide was first dissolved with 2¼ pounds of sodium hydroxide. To this solution was added 2 pounds of ordinary salt. The plants killed were comparatively small and might have been more thoroughly sprayed. Figure 23 shows how the plants were sprouting and putting on new growth five months after they had been sprayed. The roots were not killed and when the plants collapsed, joints not affected by the poison became rooted and developed into new plants, making the area covered by prickly pear larger than it was originally. On one of the test areas 70 plants were sprayed in January 1934, and in February 1937, 305 separate root systems were counted.

Observations of all work done during the winter months indicated that large amounts of poison must be applied to obtain a very high percentage of kill.

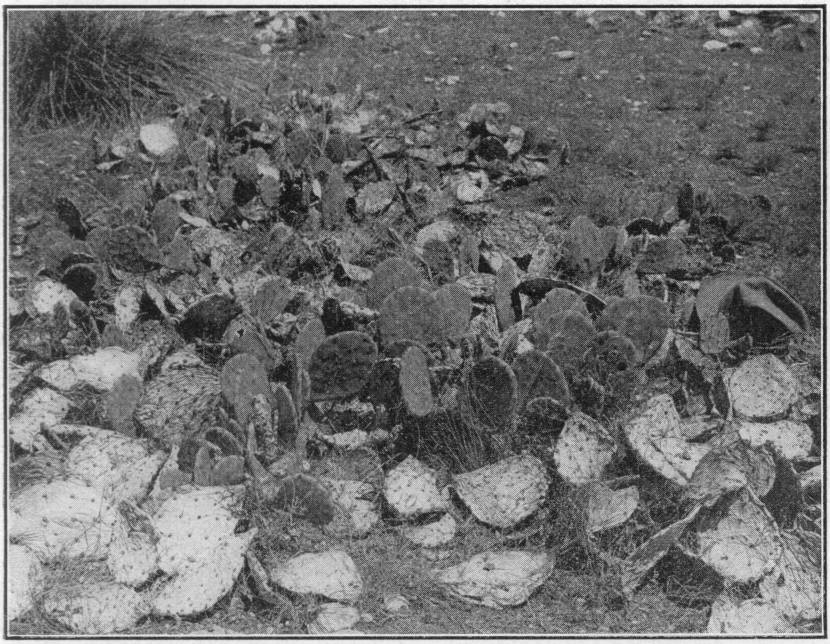

Figure 23. Prickly pear sprayed January 31, 1934. Note the new growth from parts of the plant not killed. This shows that winter spraying is not thoroughly effective and requires another application of poison to kill the plants.

Tests conducted in June 1934: Table 4 shows the various chemicals and strengths of solutions sprayed on prickly pear plants in June 1934. Counts made 11 months later showed that the best results were obtained with 2 and 3 pounds of arsenic pentoxide to 1 gallon of water, to which was added, by volume, 15 per cent commercial strength sulphuric acid. The totally dead plants were 93 and 90 per cent, respectively. Sodium arsenite and ammonium sulphocyanate had little effect on the prickly pear plant. Arsenic pentoxide solutions with no sulphuric acid did not give as good results as the solutions with sulphuric acid.

This spraying was done on a hot, clear, dry day. Observations showed that the poison first began to affect the side of the plant directly exposed

Table 4. Effects of spraying poison on prickly pear plants with an atomizer—June 21, 1934

Kind of poison	No. of plants sprayed	Time required in minutes	Part of acre	c.c. of poison used	May 30, 1935				
					Totally dead plants		Plants with joints partly alive*		
					Number	Per cent	1–2 joints	3–4 joints	5 or more joints
2 lbs. arsenic pentoxide to 1 gal. water.......	52	8	1/4.5	900	10	19	5	17	20
2½ lbs. arsenic pentoxide to 1 gal. water.....	50	9½	1/3.4	900	38	76	5	4	3
3 lbs. arsenic pentoxide to 1 gal. water.......	36	9	1/4.4	900	23	64	8	2	3
2 lbs. arsenic pentoxide to 1 gal. water, and 15% (by volume) sulphuric acid†..........	55	8½	1/6.3	900	51	93	2	0	2
3 lbs. arsenic pentoxide to 1 gal. water, and 15% (by volume) sulphuric acid...........	31	7	1/8.4	900	28	90	3	0	0
3 lbs. sodium arsenite to 1 gal. water.........	30	5	1/4.5	900	0	0	0	0	30
3 lbs. ammonium sulfocyanate to 1 gal. water.	29	5	1/6.3	900	0	0	0	0	29

*Mostly segments of terminal joints, runners, and young sprouts.

†Sulphuric acid appeared to help the poison stick to the young joints, which had a waxlike coating. Poisons without sulphuric acid did not seem to penetrate and kill the young terminal joints as did poisons containing acid.

to the sun. The sunny side of the joints first turned a pale yellow; then, as the plant collapsed and the moisture dried out, the whole joint turned a dull brown. Sunshine favorably affects the action of the poison, and a cloudy sky or foggy weather retards the effect.[1] On some tests conducted in November 1934, a .15-inch rain fell two hours after the poisons were applied. Even though this was a light shower, very poor results were obtained. It is recommended, therefore, that if rainfall or a heavy fog occurs within 24 hours after the application of poisons, the plants be given another application.

Tests conducted in October 1934: As a whole, excellent results were obtained in October 1934 with several arsenic pentoxide solutions of varying strengths. The data in Table 5 show that good results were obtained with either 2½ or 3 pounds of arsenic pentoxide to 1 gallon of water with one-half to 1 pint of commercial strength sulphuric acid. Seven months after the poison was applied 90 to 92 per cent of the plants sprayed were entirely dead. Figure 24 shows the prickly pear both before spraying and 7 months after it was sprayed.

Following heavy rains in September 1936, high water swept over the area where the prickly pear was poisoned. When it was inspected in February 1937, no dead plants could be found. In most cases the ground where large bunches grew at the time of spraying was sodded over with grass. Only 20 small seedling plants were found on the entire plot of 6 to 7 acres. The flood waters apparently aided in the decay of the prickly pear and at the same time leached out the arsenic that had been deposited by spraying.

Tests conducted in May 1935: The principal object of the tests conducted in May 1935 was to determine the effects of solutions containing 2, 2½, and 3 pounds of arsenic pentoxide. Each strength was also tested with one-half and one pint of sulphuric acid added to the solution.

A small quantity of imported arsenic pentoxide was obtained and solutions were made containing 2½ and 3 pounds per gallon of water. To each solution one-half pint of sulphuric acid was added. When the imported product was dissolved in cold water, a considerable residue of white powder remained, which was not the case with the American-made product.

Spraying was done on a partly cloudy day with a strong south wind. Three days after the poison was applied 1.5 inches of rain fell. From May to September, inclusive, there were 35.01 inches of rain, more than occurred during the years of 1933 and 1934. The ground, therefore, was more moist and the relative humidity was higher than the average. Under these conditions the poison appeared to affect the prickly pear plants more slowly but was more effective in the end. The imported arsenic pentoxide solution appeared to affect the plants more slowly than did the American product. An inspection two months after the poison was applied showed many plants with sprouts and much new growth.

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[1]C. R. Van Merwe. Prickly pear and its eradication. Science Bulletin 93, Union of South Africa, Department of Agriculture. 1931.

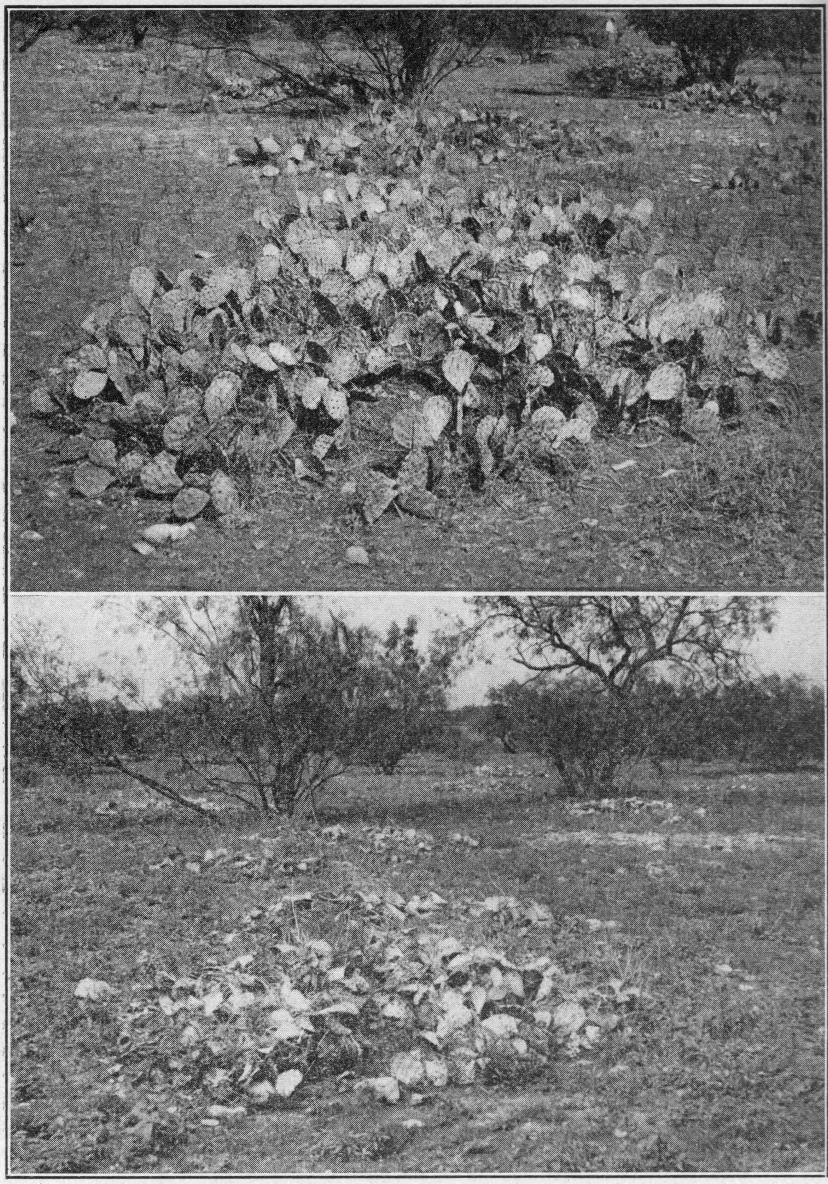

Figure 24. Above, prickly pear poisoned October 30, 1934. This picture was taken five days after the plants were sprayed. Note the light-colored and drooping joints, which show the prompt and thorough effect of poison. The days were warm and clear, with an average maximum temperature of 81° F. Below, condition of prickly pear on May 30, 1935. The plants were all dead, dry, and hard.

Table 5. Effects of spraying poisons on prickly pear plants with an atomizer—October 31, 1934

Kind of poison	No. of plants sprayed	Time required in minutes	Part of acre	c.c. of poison used	May 24, 1935				
					Totally dead plants		Plants with joints partly alive*		
					Number	Per cent	1–2 joints	3–4 joints	5 or more joints
2 lbs. arsenic pentoxide to 1 gal water, and ½ pint sulphuric acid....................	40	8	1/6.4	1500	27	68	10	2	1
2½ lbs. arsenic pentoxide to 1 gal. water, ½ pint sulphuric acid..................	38	8	1/7.4	1500	35	92	3	0	0
3 lbs. arsenic pentoxide to 1 gal. water, and ½ pint sulphuric acid..................	40	7	1/6.1	1500	35	88	4	0	1
2 lbs. arsenic pentoxide to 1 gal. water, and 1 pint sulphuric acid..................	40	9	1/5.0	1500	36	90	4	0	0
2½ lbs. arsenic pentoxide to 1 gal. water, 1 pint sulphuric acid..................	40	8	1/6.9	1500	37	92	3	0	0
3 lbs. arsenic pentoxide to 1 gal. water, and 1 pint sulphuric acid..................	35	9	1/7.0	1500	32	91	3	0	0

*Mostly segments of terminal joints, rooted runners, or young sprouts.

In February 1937, however, no live prickly pear plants were found on areas where 3 pounds of arsenic pentoxide were used. Some live base roots and rooted terminal joints were found where the 2- and 2½-pound solutions were applied. About a half dozen joints were found with green segments where the imported arsenic pentoxide was used.

Apparently, because of more rain and the higher humidity of the atmosphere, the dead prickly pear decayed and disintegrated more rapidly than when killed during dry periods. So much of the dead prickly pear had decayed and so much grass had grown over the spots where the plants had been sprayed that it was difficult to distinguish the places where they once grew.

Tests conducted in June 1936. The same poisons were used in June 1936 as in May 1935, except that the 2-pound solution of arsenic was dropped. During the eight months preceding June, less than 10 inches of rain fell. Over half this amount, or 5.12 inches, occurred in May 1936. The data in Table 6 show that the best results were obtained where it required 15 minutes to spray 50 plants, while poorer results were obtained where more rapid work was done and 60 to 75 plants were sprayed in 8 to 10 minutes. This possibly indicates that care in spraying the plants with the poison is an important factor in complete destruction.

Equal quantities of the imported and American-made arsenic pentoxide applied to prickly pear plants indicated that the imported was not as potent as the American-made.

Influence of Seasons and Climate on Effects of Poisons

With the meager funds available for this work, it was not possible to conduct tests each month of the year, but an attempt was made to conduct a test for each season. Winter spraying of prickly pear was not so effective as summer applications. Best results were obtained during the months from June to September, inclusive; however, if spraying is done carefully, good results can be obtained from May to October, inclusive.

Poisons are more effective when applied on hot sunshiny days than on cloudy or foggy days. When rain or a heavy fog occurs within 24 hours after an application is made, it should be repeated to obtain the best results. It appears that poisons are absorbed more readily and circulate to the roots and extreme joints better when the plants are in a succulent condition, well filled with moisture. Much of the prickly pear sprayed in 1933 and 1934, during a severe drought, had many leaves or joints that were thin and withered through lack of moisture.

MacDougal and Spalding, in their studies of the water balance of succulent plants, found that the joints of cactus apparently have the capacity to store some surplus water and the segments vary in thickness under varying external conditions.[1] Joints increase in thickness when

[1]D. T. MacDougal and E. S. Spalding, The water balance of succulent plants. Carnegie Institute of Washington, publication No. 141.

Table 6. Effects of spraying poisons on prickly pear plants with an atomizer—June 8, 1936

Kind of poison	No. of plants sprayed	Time required in minutes	Part of acre	c.c. of poison used	December 29, 1936				
					Totally dead plants		Plants with joints partly alive*		
					Number	Per cent	1–2 joints	3–4 joints	5 or more joints
2½ lbs. arsenic pentoxide to 1 gal. water, ½ pint sulphuric acid	50	15	1/9.4	2000	42	84	4	4	0
3 lbs. arsenic pentoxide, to 1 gal water, and ½ pint sulphuric acid	63	10	1/7.7	2000	34	54	11	7	11
3 lbs. arsenic pentoxide (imported) to 1 gal. water, ½ pint sulphuric acid	68	10	1/9.1	2000	21	31	21	12	14
2½ lbs. arsenic pentoxide to 1 gal. water, 1 pint sulphuric acid	71	10	1/8.8	2000	38	54	8	10	15
3 lbs. arsenic pentoxide to 1 gal. water, and 1 pint sulphuric acid	73	10	1/9.1	2000	43	59	17	4	9
3 lbs. arsenic pentoxide (imported) to 1 gal. water, 1 pint sulphuric acid	75	8	1/3.5	2000	32	43	19	9	15

*Mostly segments of terminal joints, rooted runners, or young sprouts.

water is added to the soil. It is not difficult to see the contrast between the thin, wrinkled segments at the end of a long dry period and the same parts which are smooth and well filled out after a rain. This is a striking phenomenon familiar even to a casual observer.

From the data collected and observations made of work done by several ranchmen, it cannot be expected that a single application of poison will destroy 100 per cent of the prickly pear. To do so would require extremely careful application and a waste of poison. The addition of rhodamine B dye is helpful in cutting down the percentage of prickly pear that may be overlooked in spraying.

Cost of Eradication

Even though the time required, quantity of poison used, and areas covered were recorded in conducting the various tests, conditions were not comparable to large-scale operations. When spraying for short periods of time, the operator no doubt worked faster and moved from plant to plant more rapidly than the ordinary laborer. Equipment and materials for refilling the sprayer were near and less time was consumed in returning for supplies. For these reasons costs were not calculated for each test made but were based on work where a number of acres of typically infested pasture was cleared of prickly pear.

The cost of killing prickly pear by poisoning will vary according to the abundance of the plants and will be influenced by the efficiency of the crew and general management. An acre having from 30 to 40 plants can be poisoned at an average cost of 50 cents. If there are only a few plants per acre, the cost may run as low as 25 cents. Where there is a dense stand, the cost to poison may range from $2.50 to $3.00 an acre.

With a well-organized crew (Figure 25) Victor Pierce of Ozona poisoned eight sections of prickly pear at an average cost of 65 cents an acre. This was done on a rather rolling, broken topography, which is typical of the Edwards Plateau region. There were level, open plains on the divides with comparatively rough hillsides dipping off into valleys, some of which were covered with a dense growth of brush.

Handling the Poison

In handling prickly pear poison the following precautions should be observed:

1. When the sprayer is filled, care should be taken not to get the poison on the hands or clothing. If the hands become wet with the poison, they should be thoroughly washed immediately before the poison dries on the skin and possibly some is absorbed through the pores. If the clothing becomes damp or wet with the poison, it should be removed and that part of the body that became damp by contact with it should be bathed to remove any poison.

2. Care should also be taken not to breathe the mist created by the sprayer in operation. Breathing this mist is dangerous, because the poison is distributed through the body quicker than when absorbed through the skin. Of course, if a man handles the poison only occasionally, there is less danger than from constant day after day contact with it. The absorption of the poison becomes accumulative and may soon cause serious trouble if the proper precautions are not used against absorbing it through the skin and lungs.
3. If poison gets under the fingernails or on sores, wash in water. Handle the poison as little as possible with the bare hands. A good pair of rubber gloves would be a good investment.
4. Physicians say that the first signs of arsenic poisoning in humans is indicated by a puffiness under the eyes.

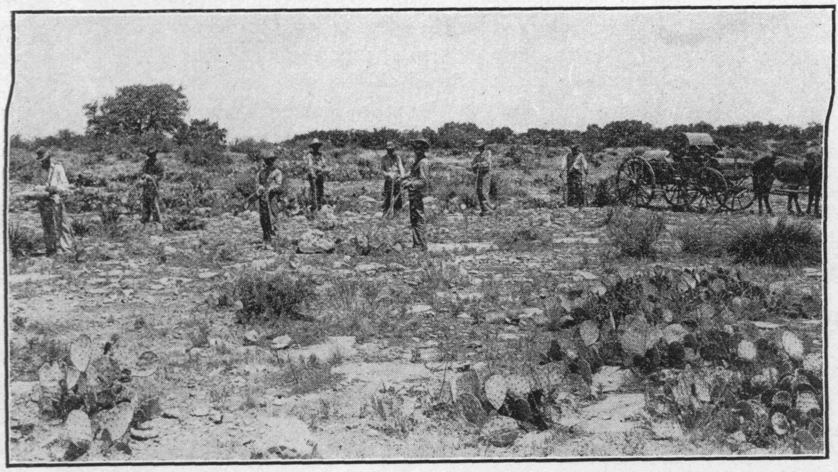

Figure 25. Crew spraying prickly pear on a ranch near Ozona, Texas.. A portable air compressor and a supply of poison are on the wagon.

How to Apply the Poison

The poison for spraying prickly pear should be applied in a very fine spray or atomized mist. A heavy spray wastes poison, as the liquid will run off the plant and drop to the ground. A fine mist more nearly covers all the plant, gives better results, and uses less poison.

Fill the container about *half full* and pump up to 110 or 120 pounds pressure. A pressure gage should be used to determine the pressure in the container. In filling the atomizer container, it is advisable to measure the quantity to be put in the atomizer so that the same amount will be put in each time, thereby getting more uniform atomization of the liquid.

The Australians recommend that for large plants as much poison should be placed at the *base* as can be released from the atomizer by pressing the trigger to spray *three* or *four* sharp "spits" of poison. *Each large junction must be given a sharp spit of poison,* then stand back and direct a light spray over the entire plant. *Repeat the operation from the opposite side of the plant.*

Results at the Ranch Experiment Station in spraying the Texas species of prickly pear, especially the type that runs along on the ground where each joint becomes rooted, show that care must be taken to spray both sides of the entire plant and especially the tip ends of the runners that are rooted, if both the top and the roots are to be entirely killed.

Danger to Livestock

Chemists say that arsenic does not deteriorate and will remain on vegetation until washed off by rains or the plant decays and disintegrates. Precautions, therefore, should be taken to prevent livestock from having access to vegetation sprayed with poisons containing arsenic. This is especially true if there is any salt in the poison.

Australians say that "many landholders who are experienced in the use of arsenic pentoxide and the Roberts poison allow stock to graze in the paddocks that are being poisoned and have no losses, as the poisons are applied so sparingly that it should be difficult for stock to eat enough pear to be poisoned."

The greatest danger, however, is from the stock's eating grass around a bunch of sprayed prickly pear. It is impossible not to spray the grass if a thorough job of spraying the prickly pear is done. If there is plenty of grass elsewhere than around the bunches of prickly pear, the danger may be slightly minimized. Ranchmen must, however, use their own discretion in the handling of stock when spraying prickly pear.

The greatest danger is from arsenical poisons spilled on the ground. The arsenic gives a salty taste and livestock will lick the ground and get enough arsenic to kill them.

Care of Equipment

At the end of the day all the poison in the sprayer tank should be used up and a pint or more of kerosene run through the nozzle. The tip of the nozzle should be removed and all the parts thoroughly cleaned with kerosene. A rag saturated with kerosene stuffed inside the nozzle will help to keep it in good condition.

If soda water is used to wash out the tank, pipe, and nozzle, it should be a strong solution and preferably hot, as *cleaning with cold water does more harm than good.*

When using an atomizer, apply vaseline or soft grease each time the tank is filled under the rubberized or vulcanized poppet, which fits over the nozzle jet or opening. This will prevent a groove from wearing and also help to prevent leakage. All poison should be cleaned from these parts at the end of each day. As a precaution against corrosion and sticking, the filler cap should be removed and all parts thoroughly cleaned.

Testing Metals for Atomizer Tanks

The tank and nozzle pipe on the atomizer used in the experimental work was constructed of lead-coated steel. As a result, small particles caused by the reaction of the chemicals occasionally passed through the screen and wholly or partly closed the nozzle jet hole. When this occurred, it was necessary to release the air pressure in the tank and clean out the nozzle. Ranchmen experienced similar trouble with an American-made atomizer.

It is a well-known fact that it is difficult to lead-coat steel without there being small pinholes. Unless an extra heavy coat of lead is applied, spots of considerable size may have insufficient lead to protect the steel from the action of corrosive liquids that are very acid. Arsenic pentoxide dissolved in water is rather corrosive, and when one-half to one pint of sulphuric acid is added, the solution will attack ordinary metals quickly.

So much time was lost by ranchmen as a result of the operators' having to stop and unchoke atomizer nozzles that an attempt was made to find a metal that would be resistant to the poison without the necessity of applying a lead coat. In 1936 several samples of stainless steel were treated with a strong arsenic pentoxide and sulphuric acid solution. As a result, it was found that a metal having a composition of 18 per cent chromium, 8 per cent nickel, and not over .07 per cent carbon, generally termed 18-8-S stainless steel, resisted the action of the prickly pear poison exceptionally well.

Mr. H. E. Smith, an experienced chemical engineer for the American Society for Testing Materials, became interested when the problem was presented to him and conducted some rather careful tests on the resistant qualities of several materials. The materials tested included the following:

1. Commercial sheet lead (for comparison).
2. Commercial sheet copper.
3. Commercial sheet alloy of copper, manganese, and silicon.
4. Commercial sheet special alloy steel, said to contain chromium, copper, and silicon with low carbon.
5. Sheet monel metal from railroad stock.
6. Sheet monel metal from manufacturer.
7. Sheet special molybdenum stainless steel.
8. Rubber covered steel plate, three layers of rubber—soft rubber next to metal, thin layer of hard rubber, then soft rubber on outside, all vulcanized together and to the plate.

The metallic specimens were uniformly polished, but the rubber-covered specimen was washed and wiped dry at room temperature.

The samples were placed on end in a small portion of the pear poison, which only partly covered them. Each sample was placed in a separate jar, which was loosely covered. The tests stood at indoor room temperature for 31 days and then were thoroughly washed and scrubbed under tap water. Weighings were made to within 0.5 milligrams.

Appearance of speciments before scrubbing:

1. Slight dark-gray powdery film which was easily rubbed off. Liquid colorless.
2. Below surface of the liquid the metal much corroded; bright crystalline surface; at surface of liquid three good-sized holes; also light blue, thick crust extending to top of specimen. Liquid dark blue.
3. Largely dissolved; a few very thin remnants which broke up when touched. Liquid dark blue.
4. Clean and bright; no film, crust, or other visible evidence of corrosion. Liquid colorless.
5. Below surface of liquid brownish powdery thin film which was easily rubbed off. The cleaned metal had a mat surface. At surface of liquid there was a thick light-blue crust. Liquid blue.
6. Same as No. 5, except cleaned surface still bright and surface crust slight. Liquid blue.
7. Clean and bright. No visible evidence of corrosion.
8. No evidence of attack. Surface rubber still soft and tough.

Loss of weight of metals at end of 31 days of exposure

Specimen	Actual loss of specimen	Loss in ounces per square foot
1	0.0305 grm.	0.0495
2	1.2970 grm.	2.1803
3	dissolved	....
4	0.0005 grm.	0.0008
5	0.5360 grm.	0.8712
6	0.3340 grm.	0.5429
7	0.0010 grm.	0.0016
8	No loss	....

The losses of Nos. 4 and 7 are within the possible variations of cleaning and weighing. These two specimens may be said to be uncorroded. They should also be satisfactory for use as tanks on atomizers for prickly pear poison.

Progress in Prickly Pear Eradication

According to Agricultural Adjustment Administration officials, 1,190,980 acres of range land was cleared of prickly pear by grubbing and poisoning in 1938. Because of the lack of adequate equipment and the difficulty in obtaining arsenic pentoxide, only approximately 25,000 acres were cleared by applying poison.

The arsenic pentoxide was imported largely by the Thompson-Hayward Chemical Company of San Antonio, Texas, from Belgium and Germany, and the cost to the ranchmen was approximately 9 to 10 cents a pound. Sulphuric acid was obtained from local chemical companies and rhodamine

B dye from the National Analine and Chemical Company of New York. Sprayers for applying the poison were manufactured from 18-8 stainless steel by Fritz Glitch and Sons of Dallas, Texas, for $60 per sprayer (Figure 26).

Several ranchmen have fixed up their own mixing equipment (Figure 27). This generally consists of oil drums with one end cut out and lined

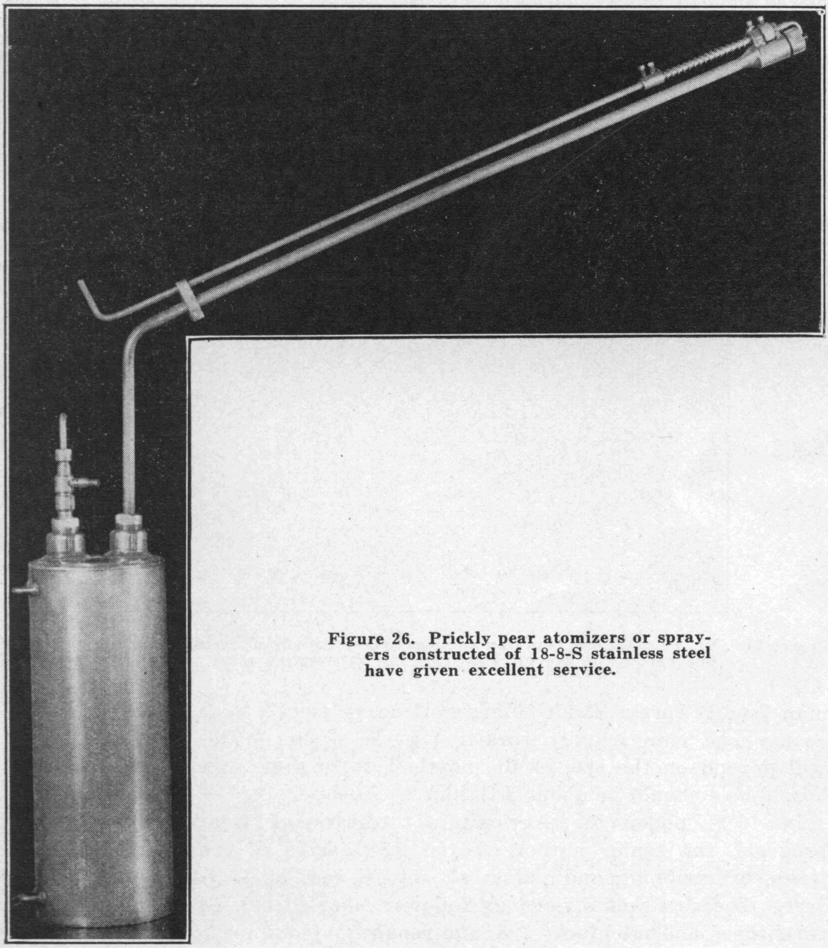

Figure 26. Prickly pear atomizers or sprayers constructed of 18-8-S stainless steel have given excellent service.

with emulsified asphalt. On the side near the bottom when the drum is set endwise a hole is punched and a three-fourths inch brass pipe is brazed over the hole. This pipe is fitted with a brass or bronze cut-off valve and an extension long enough so that liquid will flow directly into a funnel on a carboy. The drums are placed on elevated platforms about

3 or 4 feet high, so that glass carboys can be placed under the outlets for filling. One ranchman at Del Rio has a large metal tank lined with lead in which he mixes the arsenic pentoxide, sulphuric acid, dye, and water. Ordinarily a 110-pound drum of arsenic pentoxide is dumped into a drum of water to which is added 1 pound of dye and 4 to 6 gallons of sulphuric acid. The solution is run through a 100-mesh copper wire placed in lead funnels directly into the carboy. Several of these carboys are loaded on a truck and carried to a place convenient to the spraying crew. An acid pump is used to remove the poison from the carboy into one-gallon containers, at which time it is run through a strainer (Figure 28). When the poison is poured into the sprayer tank, it is strained a third time. These strainings remove any small particles of trash or undissolved lumps, preventing stoppage of nozzles and loss of time.

A good spraying crew consists of 8 to 10 sprayers (Figures 25 and 29), a boss, a helper, and a cook. On fairly level open country one

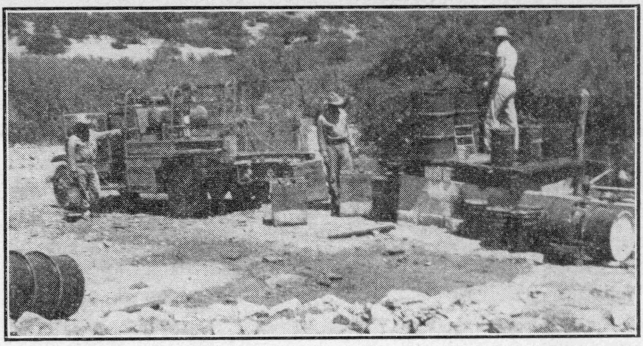

Figure 27. Mixing platform, showing mixing drums, drums of arsenic pentoxide, cans of dye, carboys on ground, and truck for transporting spray to spraying crew.

man usually sprays about 10 acres of heavy prickly pear a day. In rough county one man usually sprays 4 acres a day. The quantity applied will depend on the size of the nozzle hole to some extent. A good-sized nozzle hole should be about .018 inch in diameter.

In 1937, under the Agricultural Adjustment Administration Range program, the senior author cleared 2,880 acres of rough rocky pasture lands, by grubbing and piling, at a total cost of $1,551 or 54 cents per acre. The cost was divided as follows: labor $1,440, equipment including carts, hoes and pitchforks $96, and repairs on equipment $15. The prickly pear on 400 acres was appraised as heavy, 1,280 acres as medium, 340 acres as light, and 860 acres as below light. In 1938, 2,560 acres were cleared of prickly pear with the same equipment that was used in 1937 at a cost of $1,280 for labor.

In 1938 the Range Experiment Station cleared, by grubbing and piling, 688 acres at a flat contract price of $300. The pasture was level and had a few mesquite trees that were well distributed. The grubbed prickly pear was hauled with trucks and dumped into good size piles.

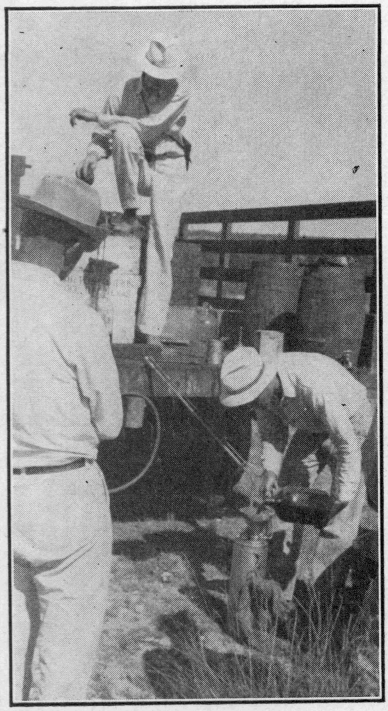

Figure 28. Showing how poison is removed from carboy with acid pump (partly hidden by hat) and how sprayers are filled.

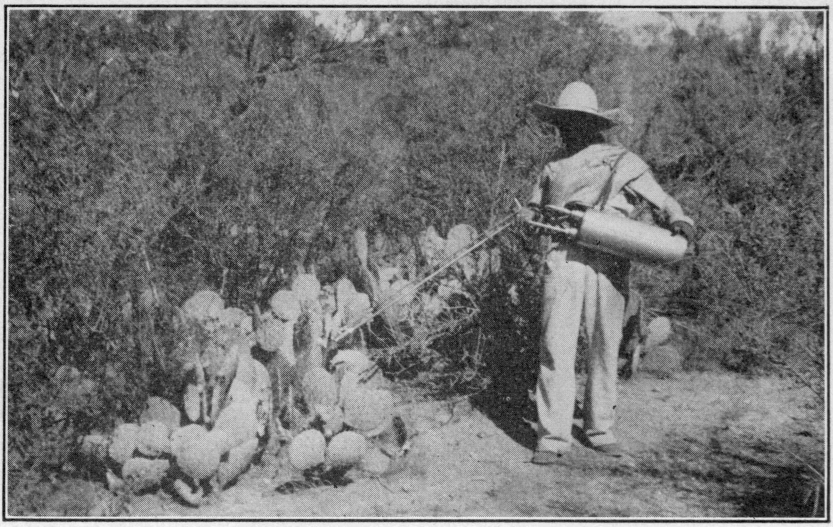

Figure 29. Mexican spraying prickly pear in brushy country.

Summary and Conclusions

Studies on the eradication of prickly pear in the Edwards Plateau section of Texas covered a period of four years, 1933 to 1937. Most of the experiments were conducted at the Ranch Experiment Station, but observations were made on the work done by ranchmen at other locations.

The cost of eradicating prickly pear by grubbing and piling ranges from 25 cents to $3.00 an acre, depending on its abundance, the topography of the country, and the general management and efficiency of the labor.

The practice of burning and grazing prickly pear exercises a certain amount of control but cannot be recommended as a method for complete eradication unless the stumps are grubbed soon after cattle have eaten the burned prickly pear.

Insects and diseases control prickly pear to a limited extent in Texas. Parasites of insects affecting prickly pear prevent their multiplying in sufficient numbers for them to be considered an eradication agency.

Grubbing, which includes piling, and poisoning are the most practical and effective methods of eradicating prickly pear from pasture lands. Spraying poisons on prickly pear plants is more effective and practical than applying them by means of stabbers or injectors.

The most effective of all the poisons tried consisted of 3 pounds of arsenic pentoxide to 1 gallon of water, to which was added 1 pint of commercial strength sulphuric acid.

Poisons should be applied with special equipment that atomizes it into a foglike mist. Best atomization is obtained with an air pressure of 110 to 120 pounds. Both sides of the entire plant, especially the terminal or end joints and base, should have a dewlike coating of the poison. Applying poisons until they drip from the plants is wasteful and unnecessary.

Best results are obtained when poisons are applied during the months of June, July, August, and September. Good results can be obtained in May and October by careful application of the poisons. If rain occurs within 24 hours after spraying, the application should be repeated.

An acre having from 30 to 40 plants can be poisoned at an average cost of 50 cents. If there are only a few plants per acre, the cost may run as low as 25 cents. Where there is a dense stand of prickly pear, the cost may range from $2.50 to $3.00 an acre. The cost is influenced by the abundance of the plants, the efficiency of the crew, and the general management.

Tests indicate that a metal alloy of 18 per cent chromium, 8 per cent nickel, and not over 0.07 per cent carbon, generally termed 18-8-S stainless steel, will resist the action of the prickly pear poison sufficiently to be used as sprayer or atomizer tanks.

Agricultural Adjustment Administration officials reported that in 1938 approximately 1,190,980 acres of range land were cleared of prickly pear. About 25,000 acres were cleared by applying poisons, but the largest acreage was cleared by grubbing.