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YIELDS OF NATIVE PRICKLY PEAR IN SOUTHERN TEXAS.

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INTRODUCTION.

When information regarding the value of prickly pear began to be demanded some years ago next to nothing was definitely known about the handling of the crop on an economic basis. Indeed, so far as known, the species of southern Texas had never been systematically planted as a crop. In consequence, some very elementary investigations were necessary in order to furnish the required information. First, it was imperative to determine the yields which could be obtained from the various economic species under cultivation. Data on this phase of the investigations have accumulated to such an extent as to warrant the publication of a summarized statement of yields secured under variable and difficult conditions. The difficulty was due mainly to meager facilities and lack of sufficient constancy and continuation in organization. Although the conditions under which the various yields have been obtained are very variable, they are perfectly interpretable, and some of them at least approach ordinary farm conditions very closely.

Yields for the first plantings made were reported in Bulletin 124 of the Bureau of Plant Industry. In this first 2-year period a yield of about 23 tons per acre was secured for each year. Since that time further observations and tests have been possible with plantings at San Antonio as well as at Brownsville. These two localities are representative of the coastal region of heavy rainfall and of the more inland situation of much more uncertain distribution of moisture.[1] In both places the rainfall is irregular, but at San Antonio it is smaller in quantity. It is neither possible nor necessary here to go into details, but the rainfall at San Antonio is not only on the average smaller in quantity but also of more irregular distribution than at Brownsville.

[1] For a discussion of the relation of the climatic conditions of the San Antonio region to prickly-pear culture, see Bulletin 124 of the Bureau of Plant Industry, entitled "The Prickly Pear as a Farm Crop."

YIELDS AT BROWNSVILLE.

THE FIRST PLANTING.

In March, 1908, the first planting of native varieties of prickly pear was made on a small scale at Brownsville. At this time two 8-foot rows 458 feet long were established on one side of a varietal collection planted the same summer. Single-joint cuttings were plowed under, as described in previous publications, at a distance of 3 feet apart in the row. This planting was given moderately good cultivation. The middles were kept clean, but often Bermuda grass and other vegetation were allowed to grow in the rows.

In the latter part of October, 1909, or at the end of the second growing season, row 2 was cut and weighed. In harvesting this row, a good stump (Pl. I, figs. 1 and 2) consisting of one to four cuttings, but never over one cutting high, was left attached to the original cutting, set 19 months before. The total material harvested in this manner weighed 17,060 pounds, or 8.53 tons. This showed a yield at the rate of 100.721 tons to the acre for two seasons' growth, or 50.36 tons per acre per annum.

The first row was not harvested at this time, but was reserved until the following February to be cut and used in establishing a 6-acre planting. This row is believed to have yielded considerably more than row 2, harvested in the fall.

In considering these yields, attention should be given to several conditions. It is estimated that not less than 2 tons per acre were left on the ground in the stumps, besides the original cuttings. The increase in weight between October and March, when the 2-year period would be complete, would, in the absorption of water and in growth, amount to several tons per acre. The harvesting was done at a time when the pear contained the least moisture, for it followed a very long dry season. In short, this test is hedged about by such conditions that the results in yield as given appear to be ultra-conservative.

SPECIES PLANTED.

As previously stated, the native species of prickly pear of the Rio Grande delta are unique (Pl. II, fig. 2). They differ from any that have been encountered elsewhere. What is more, they were entirely unstudied when our investigations were begun. A reference to them is found in one of the works of Dr. Engelmann, but this is all; he had never seen any of them.

A general survey of the species of the immediate vicinity was made, and finally two species were selected which appeared to be the most promising. For the sake of comparison a third was selected from a resaca bank near Brownsville. The first two species were secured at Loma Alta, about 6 miles east of Brownsville. They were selected on account of their thrifty, compact growth in nature, the character

and number of the spines being left entirely out of consideration. The two species are very similar in stature and general habit, forming a hemispherical shrub about 4 feet high when fully grown. Since their selection and planting, they have been described—one as *Opuntia gommei* and the other as *Opuntia cyanella*.

Opuntia gommei is a bright, more or less glossy, yellowish green species with yellow flowers.

Opuntia cyanella, on the other hand, is glaucous or waxy blue-green, with flowers opening deep red but soon changing to purplish.

Both species have yellow spines and spicules in large numbers; in fact, all the native species of the delta region are among the most spiny of any of the economic species of this genus of plants, their spines and spicules being not only numerous, but large and stout. The spines are so large and stout and die and become inflammable so tardily that these delta species are among the most difficult in the genus to prepare properly as food for stock.

The first two rows previously discussed were planted to a mixture of these two species in about equal quantities.

Besides these two, a third species, which has not been botanically named, having a tall habit of growth and differing in several particulars from the others, was planted in another row, largely for comparison and to verify the writer's judgment of the species most profitable to grow. In other words, it was desirable to determine whether one with a little experience can go into a prickly-pear region which is little known and by ordinary observation unerringly select the species of most economic worth.

At the same time that the plantings of these native species were made a single row of approximately the same length as the others was set in the same way to an introduced species frequently cultivated by the Mexicans about Brownsville. It is the same as one of the Mission varieties so commonly grown in southern California. It is the spiny "tuna blanca" of the region of San Luis Potosi, Mexico, and the "tuna teca," or "tuna blanca teca," of the eastern Jalisco and Aguascalientes regions.

YIELDS.

The third row of the field was planted to this third species (the unnamed one) and it was harvested a week before row 2. The row was 463 feet long and the yield, when harvested precisely as the other, was 13,190 pounds, or at the rate of 77.03 tons to the acre for two seasons' growth. This means an average annual growth of 38.51 tons per acre, as contrasted with 50.36 tons in the case of a mixture of *Opuntia gommei* and *Opuntia cyanella*.

The introduced Mission pear yielded at the rate of 42.75 tons per acre per annum, which was greatly in excess of our expectations.

However, the results here are not quite comparable with those in the other cases, for this species was cut close to the ground. The yields, however, are good enough and close enough to those made by *Opuntia gommei* and *Opuntia cyanella* so that the species becomes one to be considered as an economic possibility, especially as it is much more easily singed than the native species. It also produces a fine quality of fruit, but the fruit often does not set well in this climate, probably owing to the excessive rainfall which is likely to occur when the crop is in blossom.

After this harvesting, all but the first two rows (a mixture of *Opuntia gommei* and *Opuntia cyanella*) were rooted out. Those left were cleaned up with cultivator and hoe and kept well tilled again for the next two years. They were harvested the second time between October 21 and December 27, 1911, or approximately 24 months from the first harvesting. (Pl. I, fig. 2.) The first row yielded at the rate of 191.088 tons per acre and the second at the rate of 236.286 tons, or 95.544 and 118.143 tons per acre per annum, respectively. Averaging these, we have a yield at the rate of 106.843 tons per acre per annum of green, succulent feed.

Late in February and early in March, 1910, a 6-acre planting was established upon an area contiguous to the above. This was planted on poorly prepared land, a part of which was flooded at times and all of which contained more or less Bermuda grass. For the next two years this area was cultivated, but it was, of course, not possible to give it the best tillage, because of the existence of the Bermuda grass and the refractory character of the Cameron clay which extended in a shallow swale diagonally across it. This planting, made to meet the requirements of a feeding experiment conducted by the Bureau of Animal Industry of this department, was harvested according to the demand for the feed between October, 1911, and May, 1913. On account of its being harvested over the entire growing season of 1912 it is not possible to include all of the data, but the weights at the time of harvesting were kept by rows. Consequently, only those rows harvested during the dormant season are available and comparable with other figures obtained elsewhere.

Although this crop can be harvested and fed at any time of the year, estimates of its yield can best be made during the season that the plants are the most dormant, and in order to be exactly comparable they should be made during the same time of the year. Dormancy is only a relative term here, for while no apparent new growth takes place during the winter months, except in heavily pruned plants, there is little doubt that they actually do increase in weight during their dormant period.

As stated above, the harvesting of the 6-acre planting was done as the feed was needed. This planting was contiguous to a varietal

FIG. 1.—A FIELD OF CULTIVATED NATIVE PRICKLY PEAR AT BROWNSVILLE, TEX., SHOWING THE GROWTH FROM SINGLE-JOINT CUTTINGS AT THE CLOSE OF THE SECOND YEAR, ONE ROW HAVING BEEN HARVESTED.

FIG. 2.—ANOTHER VIEW OF THE FIELD ILLUSTRATED IN FIGURE 1, SHOWING THE GROWTH OF TWO YEARS FROM THE STUMPS LEFT AT THE FIRST HARVESTING.

FIG. 1.—A 6-ACRE PLANTING OF NATIVE PRICKLY PEAR AT BROWNSVILLE, TEX., ABOUT THE MIDDLE OF THE SECOND SEASON'S GROWTH.

FIG. 2.—NATIVE UNCULTIVATED PRICKLY PEAR GROWING NEAR BROWNSVILLE, TEX.

collection of prickly pear and agaves, the rows being numbered consecutively, the 6-acre planting beginning at row 20. The yields of rows 20 to 48, inclusive, together with the time of harvesting and the other data necessary to computations and a proper interpretation of them, are given in Table I.

TABLE I.—*Dates of harvesting and yields of native prickly pear at Brownsville, Tex.*

No. of row.	Date of harvesting.	Yield per row.	Length of row.	Total yield per acre.	Annual yield per acre.
	1912.	*Pounds.*	*Feet.*	*Tons.*	*Tons.*
20	Jan. 5 to 13	7,340	501	39.615	19.807
21	Jan. 14 to 20	6,576	501	35.492	17.746
22	Jan. 20 to 30	9,302	501	50.204	25.102
23	Feb. 1 to 12	12,062	499	65.362	32.681
24	Feb. 14 to 28	13,626	500	73.689	36.844
25	Mar. 1 to 15	12,591	501	67.956	33.978
26	Mar. 16 to Apr. 1	13,885	499	75.240	37.620
27	Apr. 1 to 25	17,662	498	95.899	47.949
28	Apr. 9 to May 14	21,662	498	117.619	.....
29	May to June	21,662	495	118.331	.....
30	May 15 to July 10	23,476	494	128.500	.....
31	June 4 to July 14	24,169	490	133.373	.....
32	July 15 to Aug. 14	25,957	497	141.221	.....
33	Aug. 16 to Sept. 21	22,531	489	124.588	.....
34	Sept. 24 to Oct. 21	33,470	487	185.837	.....
35	Oct. 22 to Nov. 12	23,525	484	131.428	43.809
36	Nov. 13 to 20	30,224	498	164.108	54.703
37	Nov. 21 to 26	24,239	481	136.262	45.420
38	Nov. 27 to 30	22,708	487	126.083	42.027
39	Dec. 1 to 7	27,306	475	155.443	51.814
40	Dec. 7 to 13	25,268	471	145.063	48.354
41	Dec. 13 to 17	19,488	468	112.597	37.532
42	Dec. 18 to 24	25,476	464	148.463	49.487
43	Dec. 24 to 28	22,005	459	129.633	43.211
	1912–13.				
44	Dec. 29 to Jan. 2	24,249	463	141.618	47.206
45	Jan. 1 to 7	23,718	460	139.421	46.474
46	Jan. 8 to 11	17,160	456	101.756	33.918
47	Jan. 13 to 17	20,216	451	121.206	40.402
48	Jan. 18 to 23	27,078	451	162.347	54.116

It will be seen that the yields are very variable. This is due principally to the varying conditions of the soil. Attention has been called on another page to the low depression running diagonally across the field. This was of stiff Cameron clay, very refractory and difficult to cultivate and flooded at times. Another cause of the differences in yield was the greater prevalence of Bermuda grass in some places than in others.

With reference to rows 20, 21, and 22, it should be stated that the low yields were due to still another factor. The stock for planting these three rows was, contrary to expectations, secured from material cut and dumped into a waste pile several months before. The cuttings were badly withered, and, being planted in very dry soil in a season followed by a long dry summer, they did not start well. Many of the cuttings failed to grow, making the stand poor. During the entire two seasons it was very noticeable that these rows were much lighter than the contiguous rows of the same species but of good stock.

In the last column of Table I the annual yield has been omitted in those rows harvested during the growing season, for reasons already stated. An average of the others gives a yield for the portion harvested during the crop's dormant season of 40.463 tons per acre per annum. Omitting rows 20 to 22, inclusive (which is justifiable on account of the poor stand), the average yield per acre per annum is 43.557 tons. It should be borne in mind that a part of this is averaged for two years' growth and a part for a three-year period. In other words, rows 20 to 27 were harvested after two seasons' growth and rows 35 to 48 after they had attained the growth of three seasons.

The species of prickly pear grown in these experiments were a mixture of the three discussed on page 3, but *Opuntia gommei* and *Opuntia cyanella* greatly predominated. The quantity of the other species grown was negligible.

In addition to what has been said regarding the handling of this plantation, it should be stated that no cultivating at all was done after the second season. Cuttings were set in this planting, as in the other, in 8-foot rows, no attempt being made to space them exactly. Under these conditions, the plants had bridged over the 8-foot rows at the close of the second year's growth to such an extent that animals could not pass through and cultivation had to be abandoned. (Pl. II, fig. 1.)

CONDITION OF THE PLANTATION.

The condition of the plantation was first class during the entire period up to late in the winter of 1913. At this time the common fungous diseases of the region began to be alarmingly prevalent; indeed, so much material had to be discarded in feeding that accurate estimates of yields could not be secured after the first of March. The cause of this condition was not difficult to interpret. The season of 1912–13 had an abnormal rainfall and a winter temperature with a high minimum. Weeds and grass grew thick among the plants and remained green for the most part during the entire winter. The pear itself had grown into an impenetrable thicket, furnishing the best conditions possible for the development of the fungi.

In this region it seems as though the age of the plantation when harvested will have to be considered more than in any other in which we have worked, because of the liability of the development of various diseases when the thicket becomes so dense as to prevent the aeration of the inner delicate vegetative parts. It is possible that when grown under usual conditions it will be necessary, in order to secure the best results, to harvest at from 18 to 36 months rather than let the crop stand for longer periods, as is possible in the San Antonio region or farther inland in general. The common diseased condition of the prickly pear in the brush about Brownsville points to its suscepti-

bility to disease in this region. In all regions, however, much growth is lost after the plants attain a certain size. Even at San Antonio the joints that are heavily shaded in the center of the plant either rot or dry up when the plant is about 3 years old. This means that these plants, like trees and shrubs in general, go through a process of natural pruning which lets light and air into the center of the plant. This natural pruning takes place everywhere, but much more tardily when growth is less rapid.

A summary of the conditions and of the yields obtained at Brownsville is given in Table II.

TABLE II.—*Summary of yields of native prickly pear grown from cuttings or old stumps at Brownsville, Tex.*

Time harvested.	Character of cultivation.	Cuttings or stumps.	Yield per acre per annum.	Species grown.
			Tons.	
October, 1909	Good	Cuttings	50.32	Opuntia gommei and Opuntia cyanella.
Do	do	do	38.42	Unnamed.
Do	do	do	42.75	Mission.
Oct. 21 to Dec. 27, 1911	do	Stumps	106.843	Opuntia gommei and Opuntia cyanella.
Dormant seasons of 1912–13	Good for two seasons; none thereafter.	Cuttings	40.314	Mainly Opuntia gommei and Opuntia cyanella.

YIELDS AT SAN ANTONIO.

Since the publication of the last bulletin [1] detailing the conduct of experiments at San Antonio, Tex., 8 acres of prickly pear, mainly of *Opuntia lindheimeri*, have been grown and harvested from time to time as the condition of the plantings appeared to warrant. An effort has been made on all occasions to make the test practical and comparable with other crops grown in the same vicinity. Although it has not been possible to secure the cultivation deemed necessary, possibly even this brings a closer approximation to usual conditions.

During the entire time that the experiments have been carried on the cultivation has been poor. It has been below the average for farm work in the region; indeed, in nearly every period there was a year with no cultivation at all, and in no case did cultivation to the extent of conserving moisture obtain at any time. The handling has been what could very properly be called poor farming.

YIELD WITHOUT CULTIVATION.

On March 3, 1911, a harvesting was made of an acre of uncultivated planting established five years before. In this instance furrows were opened up with a plow on the native unbroken sod of the region after the mesquite and other shrubs had been grubbed off. The cuttings

[1] Bureau of Plant Industry Bulletin 124, 1908.

were distributed at the side of the furrow and partially covered by pulling the sods back on their bases. No attention was paid to this acre of ground after it was planted. The area was fenced, however, in order to keep stock out of some varieties which were originally planted in an adjoining acre of ground, but the handling in this respect was not at all uniform, for part of the time the cattle were allowed access to the field, when the grass and other vegetation on the plat were grazed closely, like the other native pastures on the place and in the vicinity.

This plat of ground, besides furnishing information on this particular subject, throws important light on the handling of pastures in general. Its irregular, periodical harvesting by dairy cattle, which were herded on the acre of ground on two occasions, showed conclusively that this acre, besides growing the crop of prickly pear, actually furnished more grazing than any other like area of native pasture on the farm. This result was due to periodical as contrasted with continuous grazing. Of course, an exact quantitative comparison between this plat and the remaining native pastures of the farm is obviously impossible, except in so far as one is able to judge from the total results of the farm pastures as compared with the number of animals fed for single days on this acre.

Under the above conditions, which are the same as those of the native cleared pastures of the region except in so far as the periodical grazing and the actual planting of the cuttings may affect the growth of the pear, there was a very low production as compared with even the poorly tilled soil. The growth was of such a character as not to warrant harvesting until after it had attained an age of 5 years instead of 3 years in poorly cultivated and 2 years in well-cultivated ground.

At the end of a 5-year period this acre of ground yielded a crop of 58,920 pounds, which is 29.46 tons, or 5.89 tons per acre per annum. The harvesting was done in a manner comparable with other harvestings discussed elsewhere, leaving small stumps for future growth. The distances apart here were the same as in the cultivated plantings.

Three years later a representative number of rows were again harvested from this area, the growth being, of course, from the old stumps left at the previous harvesting. The yield this time was at the rate of 9.8 tons to the acre each year. Here, as in all other experiments thus far conducted, the growth was considerably greater from old stumps than from freshly set cuttings. This is simply due to the greater productivity of well-established plants.

A few representative rows of this uncultivated acre were harvested at the end of the second growing season and reported upon in Bulletin 124 of the Bureau of Plant Industry. The yield obtained was at the rate of 2.83 tons per annum.

YIELD WITH CULTIVATION.

In April and early May, 1909, there were harvested 3 acres of prickly pear planted in March, 1907. The ground was put in a good state of cultivation when the cuttings were planted and was kept fairly well cultivated the first year. The second year it was given no cultivation.

It was not possible at this time to get weights. The best that could be done was to determine the length of time the area would feed a definite number of dairy cows all the roughage they would consume.

During the feeding there was an extraordinary amount of waste, for here, as in all other cases which have come under our observation, cattle, when their feed is abundant, reject the young growth until the joints are well filled out. The fact that the harvesting was done late in the third growing season does not, therefore, in all probability, introduce any appreciable error into the calculations if the current season is discarded in our reasoning. All the roughage consumed for 1,510 cow-days was furnished by these 3 acres of a 2-year-old crop. This is equivalent to a production of roughage for five cows on 6 acres of ground. When the entire lack of cultivation and the second and only moderate cultivation the first year are taken into account, this yield is comparable with more accurate harvestings made by weighing on another occasion.[1]

In March and April, 1910, another 3 acres of the same field were harvested by being cut and a representative area was weighed. This area was handled the same as the other 3 acres the first two years, and was left and cultivated again the third year. The yield was at the rate of 14.32 tons per acre per annum.

This field was fenced and cattle kept out until the plants were well started; then the gates were left open and cattle allowed to enter the field at will. They did much to keep down certain weeds and native grasses.

In March, 1913, 1 acre of a 3-year-old crop, set from single-joint cuttings in the usual way in the spring of 1910, was cut and weighed. The crop was grown upon land which had been set to a varietal collection for four or five years. It was in a good state of cultivation when planted, so far as weeds were concerned, but it was very dry and cloddy. During the first year the cultivation was satisfactory; the second year it was all but abandoned, and during the third year an ineffectual attempt was made to keep the weeds down. In all, the tract was not over half cultivated during the entire period.

The harvesting was done from March 12 to March 25, 1913, and good stumps were left for future growth. The yield under the circumstances was very satisfactory, a total of 124,114 pounds being secured. This is at the rate of 20.685 tons per acre per annum.

[1] See Bureau of Plant Industry Bulletin 124, 1908.

It should be stated that this growth was not all from cuttings. About four rows of the old varietal plantings were preserved, and to this extent the crop was from stumps which had previously had a crop taken from them. The plantings here, as in the other cases at San Antonio, are made approximately 2½ feet apart in 6-foot rows. The varieties grown here are the same as those discussed in previous publications. *Opuntia lindheimeri* has been the principal species, but there has been a small admixture of *O. ferruginispina*, *O. sinclairii*, and other less important species.

In April, 1914, another harvesting of a representative area was made by cutting and weighing two 8-foot rows 416 feet long. The yield for the three-year period from the well-established stumps of the previous harvesting in 1910 was at the rate of 28 tons to the acre each year. During the season of 1910 this area was plowed with a turning plow and cultivated with a spike-tooth harrow three times, which, because of the harvesting and burning over of the previous spring, put the ground in fairly good condition, especially for the penetration of moisture. All the cultivation given consisted in going over the land two or three times with a spike-tooth harrow in 1911. The increase here over the other harvestings, due, it is believed, to the greater vigor of the old established plants, is striking. The beneficial effect of placing the land between the rows in good tilth, even if it be only once in four years, is also shown without doubt. Attention should be called to the fact that no handwork was done in this field after the planting.

A summary of the conditions and of the yields of native prickly pear obtained at San Antonio is given in Table III.

TABLE III.—*Summary of yields of native prickly pear grown from cuttings or old stumps at San Antonio, Tex.*

Time harvested.	Character of cultivation.	Cuttings or stumps.	Yield per acre per annum.	Species grown.
			Tons.	
October, 1907	None	Cuttings	2.83	Opuntia lindheimeri.
April and May, 1909	Very poor	do	(1)	Do.
April, 1910	do	do	14.32	Do.
March, 1911	None	do	5.89	Do.
March, 1913	Poor	do	20.685	Opuntia lindheimeri mostly.
April, 1914	do	Stumps	28.00	Opuntia lindheimeri.
Spring, 1914	None	do	9.8	Do.

[1] Roughage for 1 cow on 1¼ acres.

GENERAL CONDITIONS AFFECTING YIELDS.

As shown by the figures cited, other conditions being equal, the yields of prickly pear at a particular place have generally been in direct proportion to the care given the plantation. The most potent factor after the plants are once thoroughly established is cultivation.

The pear does not seem to require anything like a dust mulch or deep cultivation, such as is so commonly practiced with other crops in dry regions. All that experience seems to indicate as necessary is to keep down the weeds, which interfere with the growth of the pear the same as with any other crop. Shallow cultivation appears to be sufficient, but, owing to the fact that our plantations at San Antonio have at times become very weedy, a shallow furrow has been turned toward the rows and subsequently leveled with a spike-tooth cultivator. In our two situations, the maintenance of a dust mulch has not seemed necessary, even in the driest seasons.

In one of our varietal plantings at Brownsville, established upon an old Bermuda-grass sod, a good dust mulch of 2 to 4 inches seemed to be very detrimental. In this case we were dealing with resaca-bank loam in a perfect state of tilth for two years. Under this treatment there was a constant and abundant supply of moisture in the soil. The growth of all species was very rapid for a short time, but they soon rotted off at the surface of the ground, and this condition continued at an alarming rate for two or three seasons after the establishment of the plantation. The spineless and introduced species suffered most, but the native species rotted off also. They simply fell over and took root again on top of the ground, thus becoming reestablished and still making a phenomenal growth. Under these humid conditions a deep dust mulch was decidedly detrimental. Treatment which allowed the soil to dry out more readily was productive of better results. In short, upon the heavier lands of southern Texas, represented by the regions in which this work has been done, a dust mulch does not seem to be essential, but it is necessary to keep down the weeds and give sufficient cultivation to allow a good penetration of moisture at the time of rainfall.

At Chico, Cal., where the summers are long, hot, and dry, all species except those from our driest deserts have withered badly when weeds were not kept out, but when cultivated sufficiently to keep them down no wilting occurs. The desert forms have shown no signs of withering at Chico, even when no cultivation or irrigation was given. Even with poor cultivation, plantings of native prickly pear at Brownsville have never suffered from drought, although the same plants occasionally wither in the brush in the vicinity. At San Antonio our poorly cared for and weedy plantings were often considerably withered. The cultivation there has never been sufficient to do much in the way of conserving moisture, but has usually been enough to cause a good penetration of the rainfall. When no weeds were present the evaporation of this rainfall from a poorly cultivated surface has not caused the plants to wilt.

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