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IRRIGATION BY MEANS OF UNDERGROUND POROUS PIPE

By E. B. HOUSE

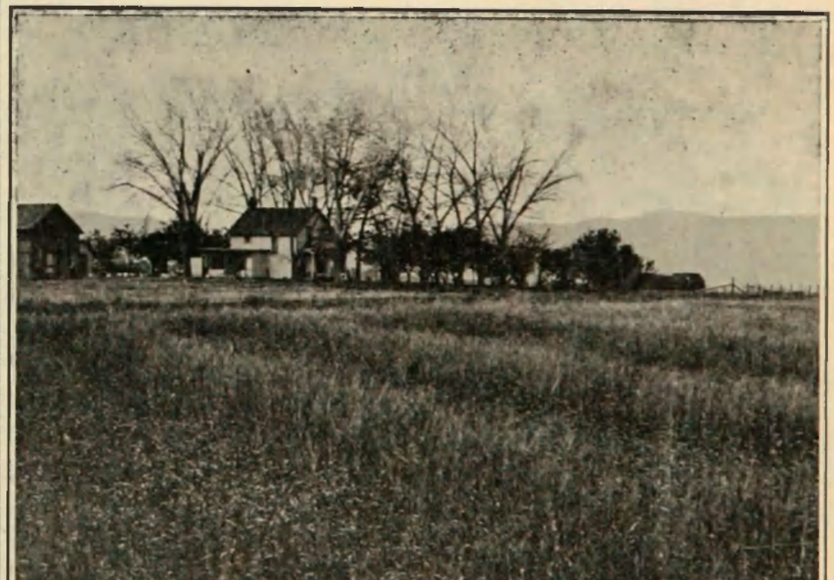

Fig. 3—Subirrigated grain

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IRRIGATION BY MEANS OF UNDERGROUND POROUS PIPE

By E. B. HOUSE

Many inquiries come to the Colorado Experiment Station from farmers of the State, concerning the installation of underground pipes for the purpose of sub-irrigation. This agitation on the part of the farmers is largely due to articles and advertisements published by our farm journals, daily papers, and weekly press, concerning this method of irrigation and the possibilities of tremendous crops whenever this system is installed. In order that these inquiries may be fuly answered as far as certain sections and certain soils of the State are concerned, this bulletin is written.

In 1913 a business firm in the State of Colorado requested the State Agricultural College to allow them to install, on land to be chosen by the college, a subirrigation system. The Station in return was to furnish them with the data collected, and also with the conclusions to be drawn from these data. It was also agreed by both parties that a bulletin was to be published after the experiment had been running a sufficient time to give fairly reliable results.

A piece of land satisfactory to all parties was selected on the West College Farm. The area of this piece of ground was approximately 2½ acres. There was growing on the land selected for the experiment (1) an apple orchard, covering about one-third of an acre, (2) an alfalfa field of .7 acres, one year old at the time the subirrigation system was installed, (3) across the road to the north a tract of ground having an area of 1.6 acres. This land had just been plowed and upon this tract, it was planned to try out different cereal crops.

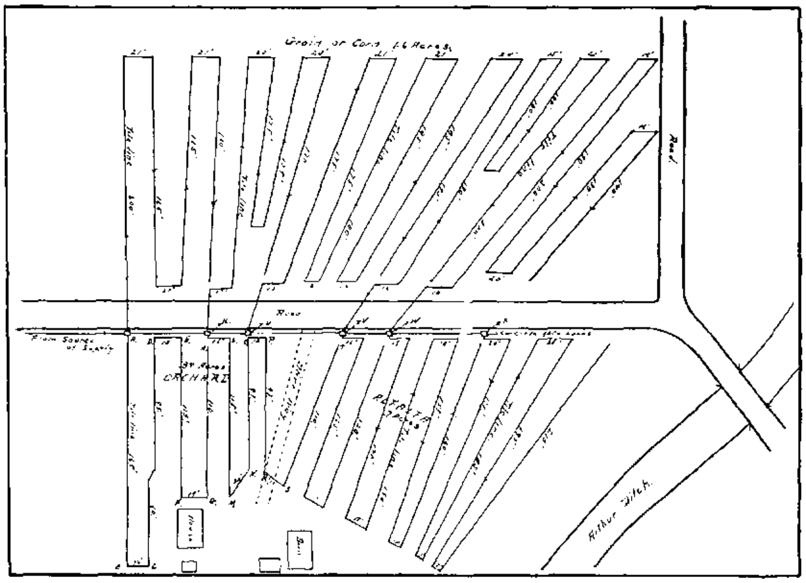
WATER SUPPLY

The water for the subirrigation system was supplied by a drain, the outlet of which entered an irrigation ditch on the College farm, some 250 feet west of the tract chosen for subirrigation work. This drain furnishes an ample supply of water throughout the year for the purpose of subirrigation, but the quantity varied somewhat at different seasons. At no time, however, did the supply drop to so small a quantity as to make it impossible to keep the subirrigation pipes full.

INSTALLATION

The company sent their expert to plan and supervise the construction of the system. Figure 1 shows the plan of the subirrigation system as laid out by this expert.

Under his direction a careful survey was made and the pipe lines staked. These pipe lines coincided approximately with the contour of the ground. It should be stated that the orchard is practically level north and south, with a slight fall as one passes to the east. The alfalfa field is on a side hill, sloping down to the Arthur Ditch, the maximum slope being southeast. The grain field to the north of the road, however, has not as great a slope but it is similar in character to the orchard and alfalfa field mentioned above.



PLAN OF SUBIRRIGATION SYSTEM

Fig. 1

DESCRIPTION OF SYSTEM

It will be noted from Fig. 1 that the subirrigation system as installed consisted of a main supply line of 6-inch porous tile, running from the outlet of the drain connected with and supplying water to the four concrete wells, or boxes, marked A, K. U, V, W and X. Details of these boxes are shown in Fig. 2.

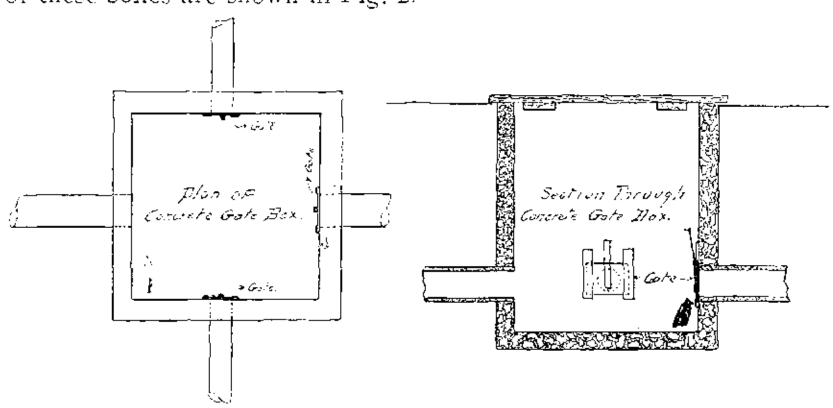


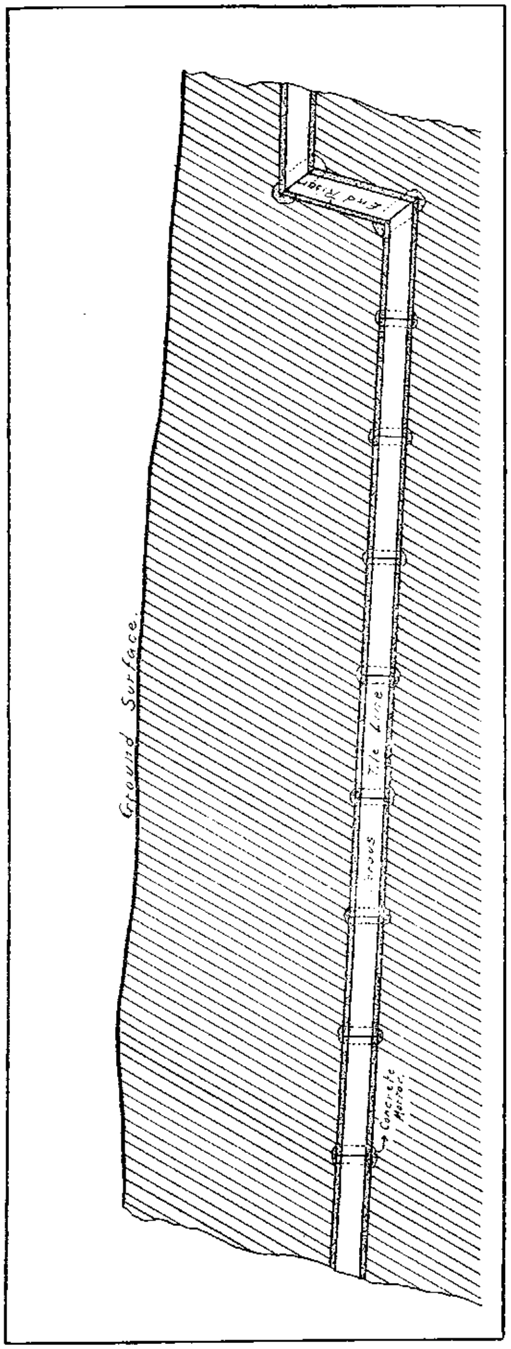
Fig. 2

These boxes were constructed of concrete. They were 2 feet square at the top and 2½ feet deep. The side walls and bottom were 3 inches thick. Gates were placed in each box that the water supply in all lines leading from the box might be controlled. These gates were of ordinary galvanized iron, fitted in slides and placed so as to cover the entrance to the pipe line running from the box.

From Fig. 1 it will be noted that the subirrigation system was laid out in sections. Section No. 1 is made up of the lines A-B; B-C; C-D; D-E; E-F; F-G and G-H, the section ending at point H. Section No. 2 takes its water from the box K, and is made up of the lines K-L; L-M; M-N; N-O; O-P; P-R; R-S; and S-T, the section ending at point T. The remaining sections are similar and may be easily followed on Fig. 1.

SLOPE OF LINES

The long lines, such as A-B; C-D; E-F; etc., were carefully laid on a grade of 1/10 of a foot per 100 feet. These lines were so laid out on the field that this grade could be obtained and the lines kept approximately 2 feet below the surface at all points, except the extreme end of each line. The short connecting lines such as B-C; D-E; F-G;, etc., were given the grade of the country at that place. These connecting lines vary from 7 to 30 feet in length and there may be a fall as great as 1 foot in this distance. In other words these short connecting lines were laid "on grade" but the grade varies with each line, the idea being simply to get down to the beginning of the next long line in order to fill that line with water and keep the same under a pressure head of approximately 1 foot.



Sectional View of Tile Line in Ground.

Fig. 3.

Fig. 3 represents a sectional view of ground and tile line. It will be noticed that at the end of this tile line is an upright section of tile called "end riser". This end riser was constructed by dressing off a section of tile and fitting it as shown in Fig. 3 to the horizontal line. This raises the end of each horizontal tile line about 1 foot in height. It is then carried at this elevation for one section of tile, (1 foot) and then given the grade of the connecting line, which is sufficient to bring the lower end of the connecting line 2 feet below the surface of the ground at the point where the short connecting line joins the next long distributing line. In Section No. 1, therefore, end risers would be found at points B, D, F and H. In Section No. 2 they will be found at M. O, R, and T.

THE TILE

The purpose of this end riser is to produce a pressure head of approximately 1 foot in each tile line before the water passes from the same, through the short connecting line, to the next long line.

The porous tile used for this system of subirrigation was a tile manufactured for this purpose by the company. It is impossible to state exactly how this tile was made and what material was put into the same. It was a secret process and the company was not at liberty to state the manner of manufacture. It may be stated, however, that these tile had the appearance of tile manufactured from cinders, sand and cement. They were guaranteed by the company to be porous enough to pass water freely, and yet to prevent any roots from entering and clogging the same. That they were porous enough to pass water was demonstrated, and also that roots from trees and alfalfa did not enter and clog the tile was also demonstrated as the experiment progressed.

The tile, however, were very soft. So soft that a great deal of difficulty was encountered in transportation. In the first shipment made fully one-half of the tile were found to be broken when the car was opened. Another shipment was ordered and that arrived in about the same condition, so that a third shipment was necessary in order to secure sufficient tile to complete the lines planned for the subirrigation system.

The tile were laid in the trench approximately 2 feet deep as ordinary drain tile are laid, with this exception, that each joint was carefully sealed with cement mortar. These mortar joints are shown on Fig. 3.

SIZE OF TILE

The tile can of course be made in any size desired, but the size recommended for the ordinary lateral line in a system of this kind was 2¾ inches, inside diameter. This makes the tile approximately 4 inches, outside diameter.

COST OF SYSTEM

The cost data for installation of this system is as follows:

300 feet 6-inch tile at 6c per foot	$ 18.00
7,382 feet 2¾-inch tile at 4c per foot	295.28
7,682 feet of trenching, laying tile and back-filling at 2.8c per foot	215.10
Hauling and distributing tile	3.48
Galvanized iron headgates	8.00
Construction of concrete boxes	18.65
Surveying	17.50
Total	$576.01

The amount of land irrigated by this system is 2.64 acres, making the cost per acre for installing a subirrigation system of this kind $218.18.

SOIL

The soil on the piece of ground covered by the subirrigation system is fairly uniform and is a deep silt loam. Just how deep this surface soil is cannot be stated, but investigations were made to a depth of 12 feet with a soil auger and they showed the same uniform silt-loam soil all the way down. It is a soil that could be called retentive, as far as moisture conditions are concerned, but it is a soil that would take water rather slowly and one would expect lateral percolation of the water to be fairly good.

SPREAD OF THE WATER FROM THE PIPES

Investigations were carried on from time to time to ascertain the spread of water from the pipe line. These investigations were made with a soil anger. Borings were made in lines at right angle to a tile line. The holes were spaced 6 inches apart. During the first part of the experiment soil samples were taken and the moisture content determined. In the latter part of the work this system was abandoned, and the lateral percolation of the water was determined by means of the soil anger alone. The results obtained in this part of the work were not very satisfactory. The data show a great variation in the lateral percolation of water from different lines, and also a large variation in this percolation of water on the same line at different places. Approximately an average condition is shown in Fig. 4.

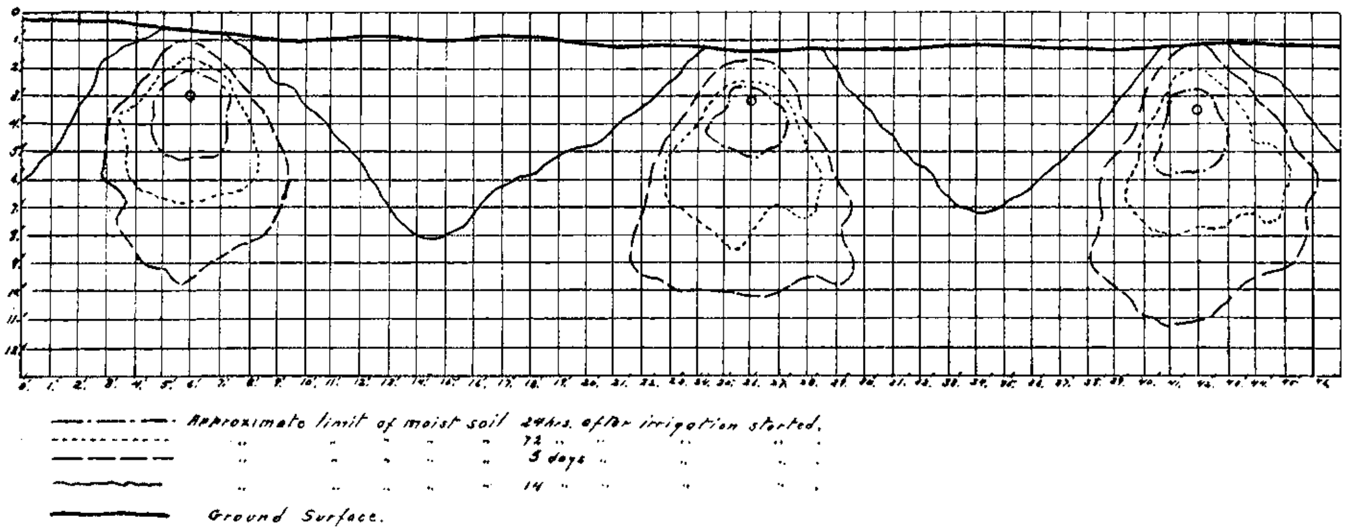


Fig. 4.—Percolation from subirrigation pipe line

Fig. 4 shows three tile lines. The first two are 20 feet apart, the second and third, 16 feet apart. It shows the progress of the percolating water from 24 hours to 14 days. The horizontal and vertical divisions represent 1 foot. From this drawing the lateral downward and upward percolation of the water may be easily ascertained. We find that, in this soil, moisture has a tendency to percolate downward much faster than to the side, and the depth of the moist soil between lines is such as to be beyond the reach of roots of many plants. This condition is further developed in studying the crops grown upon the ground and will be spoken of again.

AMOUNT OF WATER REQUIRED TO SUPPLY TILE LINES

The amount of water necessary to keep the tile lines full, varied with the amount of moisture in the soil and the length of time irrigation had been in progress. When irrigation was first started, .2 of 1 second-foot of water was sufficient to keep all tile lines full. As the irrigation proceeded it was necessary to cut down the amount of water supplied, or the water would rise in the cement boxes and overflow. During the latter part of an irrigation approximately .1 of 1 second-foot was sufficient to supply all pipe lines.

CROPS GROWN

During the four years that the experiment was in progress, the apple orchard mentioned above and shown in Fig. 1, thrived. All the irrigation water that it received was from the subirrigation system. The tile lines in this orchard were run about 4 feet to one side of a row of trees and within easy reach of the roots. The foliage of the trees would always respond to the application of water and a few days after the water was turned into the pipe lines, this foliage changed color slightly and looked fresher than it did preceding the irrigation period. No records were kept of the crop produced from this orchard as it was an old orchard and had been neglected for a number of years.

ALFALFA

The installation of the subirrigation system injured the alfalfa somewhat for the first year after installation of the system. The trenching cut out many plants, and the dirt at the side of the trench injured the first cutting of alfalfa materially for 1913. In 1914, '15 and '16, however, this alfalfa did well. The stand was even at the start and continued so. The roots of the alfalfa seemed to be able to reach plenty of moist soil, even at the midway points between tile lines. Fig. 5 shows a typical view of this alfalfa field. The alfalfa always responded immediately to the irrigation from the underground pipes, and within two days after the water was turned on at any time, the foliage of the plants would show the effect of the water.

Water was applied at intervals during one winter on this alfalfa field to show the effect of winter irrigation applied in this way. In the spring the plants started a very thrifty growth, and no injurious effects whatever were noticeable from the winter irrigation of this field.

The record of the yield from this field is as follows:

1913—Alfalfa was not cut.
1914—With subirrigation 3.02 tons.
1915—3.02 tons.
1916—1.5 tons.

Two irrigations were applied to this field in 1913, three in 1914; winter irrigation during the winter of 1914 and 1915, together with two irrigations during the summer of 1915. Only one light irrigation was given to the field in 1916.

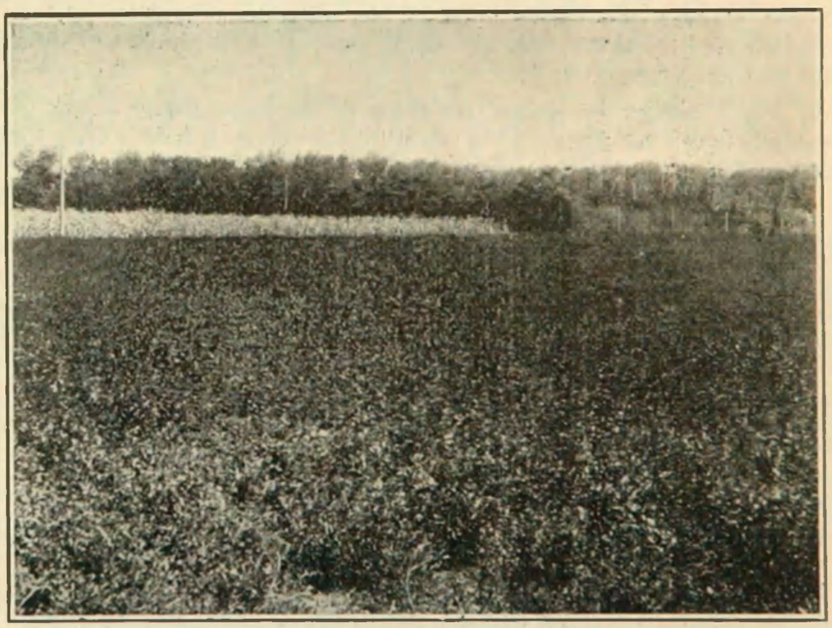


Fig. 5.—Subirrigated alfalfa

CROPS GROWN ON GRAIN FIELD

For the season of 1913, immediately after the subirrigation system was installed, the grain field was planted to barley and potatoes. The irrigation water was immediately turned on, about .1 of a second-foot, was kept running in the lines for 15 days, then shut off. The crop came up but was very spotted, and as it developed it showed a luxuriant growth immediately over the tile lines, becoming gradually poorer as the distance from the tile became greater until the middle point between two lines was reached. Especially was this true on the lines that were furthest apart and there practically no crop at all was grown.

This was true of both the potatoes and the barley. Fig. 6 is a photograph of this field, and illustrates the condition mentioned above. The crop of barley did not mature and was cut for feed. The potatoes were not worth digging. These two crops showed without question that the plants at distances greater than 5 feet from the tile lines did not receive sufficient water, and the subirrigation system was not able to supply it.

GRAIN FIELD FOR 1914

This field was seeded to wheat for the season of 1914, and although the season was fairly wet and a great deal of grain matured in this section of the country without any irrigation whatever, yet this field showed the same characteristic as mentioned for the barley field, but to a less degree.

Fig. 7 shows the spotted condition of the field due to a lack of water between tile lines. This wheat yielded about a half a crop for this season.

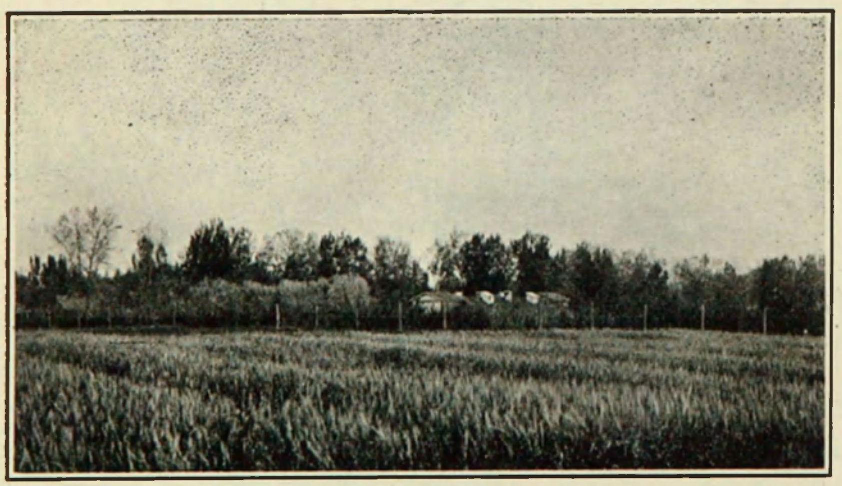


Fig. 7.—Subirrigated grain

GRAIN FIELD FOR 1915

The crop on this field for 1915 was corn, and the field produced as well as any field on the farm. This was due to the fact that the summer of 1915 was much wetter than usual. Although not a great excess of rainfall came, yet it was so distributed that the summer was without any drought and crops not irrigated did about as well as crops under irrigation. For this reason it was not considered a fair test for the subirrigation system and no records were kept for the season of 1915.

GRAIN FIELD FOR 1916

Corn was again planted on this field for the season of 1916. It came up well and for a time gave promise of again giving a good yield. The season of 1916 was normal in this section of the State, and gave a splendid test of the effect of the irrigation water upon the corn crop on this field. Two irrigations were given during the season, and at the end of the same 12,411 pounds of corn were harvested for ensilage. The corn on this field during this season showed again the injury due to insufficient water between the tile lines, and tall thrifty corn grew directly over or in the vicinity of the tile lines, with a short stunted growth midway between the same. This is well shown in the accompanying photographs Figs. 8 and 9. Figure 8 shows the corn growing upon the subirrigation tract, and it is to be noted that the stalks midway between the two lines are as high as the waist of the man standing in the field. Whereas, the corn at the right and left of him immediately over the tile line is more than 6 feet high. This is good for Colorado corn.

Fig. 9 shows an adjoining corn field planted at the same time, and given the same attention as that shown in Fig. 8, with the exception that this corn field was surface irrigated in the ordinary way. The height of this corn is uniform and is approximately the same as the height of the corn directly over the tile lines shown in Fig. 8.

Fig. 8.—Subirrigated Corn

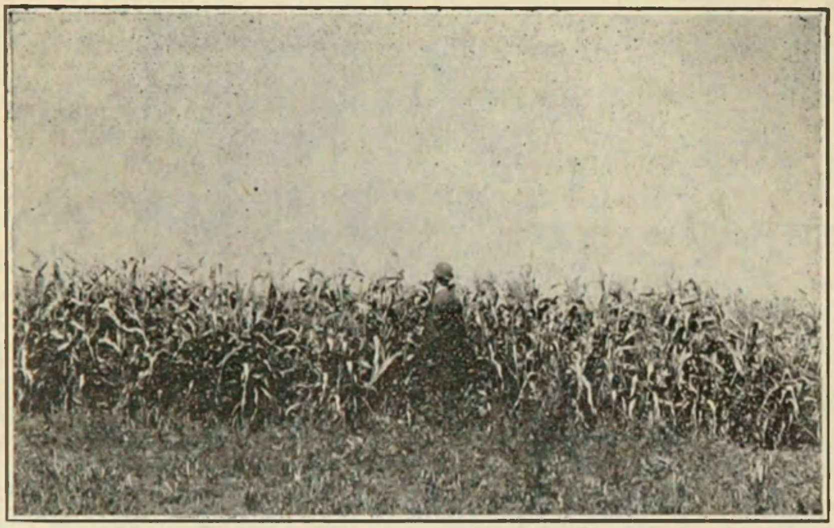


Fig. 9.—Surface-irrigated Corn

CONCLUSION

The conclusions drawn from this experiment are as follows:

1. Subirrigation by means of underground pipe is not to be recommended for any of the ordinary farm crops on account of the excessive cost for installation. It can be recommended only for the most intensive farming where water is very scarce and valuable, and only a small stream is available.

2. The lateral percolation of the water from the tile lines in deep silt-loam soil is not sufficient to warrant these lines being placed from 16 to 25 feet apart. More water percolates downward than upward or to the side, and it would be necessary to place these tile lines not more than 8 feet apart in order to bring the moisture to the roots of the growing crop. This applies to soil similar to that on the sub-irrigated field at the College farm only. It may be, and probably is, a fact that with a hard-pan or an impervious stratum of some kind slightly below the tile, and especially in early or porous soils, the lateral percolation of the water would be increased very much and the success of a system, with tile lines as far apart as 16 or 25 feet, could be guaranteed, but in deep silt-loam soil the lateral percolation of the water is disappointing.

3. With deep-rooted crops, such as alfalfa, or with orchards, this form of irrigation may be practiced with success as far as lateral percolation is concerned, but the cost of installation is so great that it cannot be recommended.

4. There has been no clogging of the lines due to the entrance of roots for the four years that the system has been in service.

5. The water used for this system was drain water which contained some alkali, but it was evidently not sufficient to cause disintegration of the tile lines as no trouble on this score was encountered.

6. A very small stream of water can be successfully used with a subirrigation system of this kind. A stream that would not answer at all for surface irrigation might be more than ample to supply a pipe system for subirrigation on a much larger area.

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