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1900

THESIS

Irrigation

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A N I R R I G A T I O N S Y S T E M

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M I C H I G A N A G R I C U L T U R A L C O L L E G E.

G e o r g e M. O d l u m.

THESIS

1. From 60 to 96% of the green weight of plants is water.

2. A large per cent of the dry matter of plants is composed of starch, cellulose, sugar etc., which are the products of water (H 2 O) and carbon-dioxide (C O 2).

3. Water keeps plants erect by keeping the cells turgid.

4. The evaporation of water from the plant keeps the plant cool, and thus protects the delicate protoplasms from the injurious heat of the sun.

5. Water makes available the materials necessary for the plant growth, carries them through the root hairs into the plant, then from cell to cell, leaving a little here and a little there, until it finally evaporates and leaves the material behind. Water is the great transportation agent of the plant economy. Experiments have shown that the evaporation of from 300 to 500 lbs. of water is necessary to the growth of one pound of dry matter.

From the foregoing it will be seen that water is a very important factor in the growth of plants, and that the successful production of crops depends largely upon the supply of water. Agricultural chemists rave about the proportions of potash, phosphorous and nitrogen necessary to the growth of certain crops, but they say very little about the water supply, thus forgetting that where abundance of water is supplied the other elements will largely look after themselves. Even the pine barrens of Northern Michigan will produce large crops when abundantly watered.

Very few sections of our country have a sufficient supply of water to produce the maximum crop that the land is capable of producing. Experiments in different parts of our country have proven this to be a fact. In Wisconsin, during the season of 1896, a season when there was a large rainfall evenly distributed, irrigated lands yielded a large increase over those that depended on the natural rainfall. And in Florida, where they have a rainfall of about 60 inches, it has been found profitable to irrigate.

How shall we furnish the plant with all the water necessary for its maximum growth? Two methods have been used,- the first is the conserving of the natural rainfall by thorough tillage. This method has proven very successful, but it is difficult to conserve sufficient moisture when you have not sufficient to start with, so that for this reason a second method is being combined with the first- that is water applied artificially to the soil.

The history of irrigation is nearly as extensive as is the history of man. It was irrigation that made the valley of the Nile the granary of the world. Babylon, Ninevah and Assyria were each in turn able to rule the world because the waters of the Tigris and the Euphrates

had been skillfully directed to water their otherwise barren plains. The Spaniard was at the height of his glory at the time when the learned Moors were patiently guiding streams over the hills of Spain. But it is not until the last half of the present progressive century that irrigation in common with every branch of industry makes its great advansive stride. The English engineer on his errand of mercy invades famine stricken India there to teach this revived art, and where he goes famine and starvation return not again. Egypt, through the reconstruction of the works of the ancient Pharoahs, again hopes to be one of the world's marks of trade. In the great West of our own America raging mountain torrents are chained to work the will of man on the fertile plains below, while here and there progressive agriculturists are forcing the passing winds to free them from their slavery to the fickle rain clouds. But as yet the great majority of farmers know but little about the proper control of their water supply. An intelligent farmer may know how to properly combine a balanced ration, he may keep the best of registered stock, he may produce a sanitary dairy product, but mention the subject of irrigation to him and he looks at you with a blank stare. To him there is a mystery about it,- it is akin to magic- a subject with which only the learned and wealthy may play. If he condecends to reply to anything so manifestly absurd it is with the curt statement that "It won't pay." He may spend $40.00 per acre on super phosphates in order to double his crop, but does

not realize that one-fourth that amount expended on irrigation may produce the same result with certainty.

Is irrigation practical, and will it pay? There are 3,500,000 acres of irrigated land in America, irrigated at an average first cost per acre of $8.00, which has placed an added valuation of $26.00 per acre. The average yearly cost is $1.00, which brings an average return of $12.00. It will be seen by these figures that irrigation pays, but these statistics are for large systems, and the expense of installing a small system is necessarily proportionally large. However, the added profit from being nearer the markets, and thus saving transportation charges, will probably make the net profit as large or larger than those given. Experiments at the Wisconsin Experiment Station have shown that even where an expensive system, uneconomically run, has been installed. it may be made to pay large returns every season.

1. Irrigation pays in that it furnishes increased crops nearly every year.

2. In that it acts as an insurance, giving remunerative crops in seasons when there would be none at all.

3. In that the water may be applied at those times when the crop needs it most.

4. In that it not only increases the quantity, but also the quality. This is especially noticeable in fruits. For instance, a peach orchard watered just before ripening will not only double its yield but the fr-

will be so increased in size as to largely grade as "choice," which sell for from two to three times as much as #2, which the fruit would have been without water. There are few "nubbins" on irrigated corn, and water properly applied to potatoes will not only increase the yield but will decrease the number of small and irregularly shaped potatoes. Many instances might be cited.

5. It pays in that it keeps the plants strong and healthy, able to resist diseases and insects. It is the weak and stunted plant that succumbs to their attacks.

6. It pays in that all water, especially lake and river waters, contain appreciable amounts of nitrogen and other fertilizing materials, and these elements added to the land in that form are at least as valuable as those purchased in the form of commercial fertilizers. In fact, most waters contain those elements in about the same proportion as the soil water taken up by the roots of plants, and many irrigated lands receive no fertilizers other than those in the water, yet produce enormous crops from year to year.

On the one hand, Michigan has a vast acreage of fertile fields, each year suffering more and more from the drougth; on the other hand, are 10,000 inland lakes, many rivers, innumerable small streams, and springs, and an unlimited supply of water not far beneath the surfade. Also abundance of cheap fuel, a nearly constant wind, and a market for all that can be raised. It is with the expectation that the farmer will soon see the relation between the foregoing and properly combine them that I take for my thesis "An Irrigation System for field #7." It is not with any idea that my work will be of any value to field #7 that I take up this work, but it is with the belief that irrigation will be one of the next great steps in the new agriculture, and I wish to so prepare myself that when that new agricultural era dawns I may be at the threshold to aid in ushering it in.

Field #7 presents no difficult problems, and will require about the same amount of work as the average Michigan field. It is an irregularly shaped field of seventeen acres, lying just south of the river and east of the College lane. It is 1,530 feet along the south side, 600 feet on the east, and 347 feet on the west side. The field is highest along the south side, and slopes to the north and east, the highest point being at about the center of the south side, which is 30.6 feet above the water in the river. The field contains a few small knolls, and two small gullies. The soil is a heavy sand loam, underlaid by a quicksand, so that it will not be best to attempt much leveling. Judging from the experience of others, it is figured that four irrigations of three inches each will be all that the field will require. This will mean 185,130 cubic feet at an irrigation, or 1,384,854 gallons. There are two available sources of water,- the river along the north side, and a well to be dug at the highest point. The depth of the well is estimated at 30 feet.

The following sources of power have suggested them-

selves: Hydraulic ram, electric motor, steam engine, gasoline engine and wind power. The first glance at the river will show that a ram would be useless because of lack of fall. The idea of electricty as power may also be dismissed, for to start with a good motor costs as much as a steam engine of equal horse power, and costs from 50% to 60% more for operation. Steam power, a threshing engine of 14 H.P. may be purchased for $1,200.00. A centrifugal pump that will deliver 700 gallons per minute to the height of 31 feet, and after allowing for losses, as friction in pipe require, 11 H.P. will cost $203.00. Five hundred feet of five inch pipe (the size necessary for this sized pump) will cost $300.00. This pipe will be enough to reach from the river to the highest point of the field, from which point an enclosed flume, with a space 8 by 12 inches, will run the length of the field on the south side. This flume would cost $300.00. It would also be necessary to have a small pump house, say at a cost of $25.00, and also to add $25.00 for the expense of laying pipe. Such a system would cost $1,853.00, and would give the field one irrigation three inches deep in three and one-third days, at a cost of $15.60 for fuel and the labor of two men, or at an expense of about $.90 per acre for one irrigation, or $3.60 per acre per season.
But the expense of this system argues against it, but we must remember that the addition of $500.00 to this first cost would make it capable of irrigating 100 acres instead of 17 acres. The engine of such a system could

be used for cutting silage, grinding feed, threshing, etc, and thus materially decrease the cost of irrigation, for if the engine were used for no other purpose the interest on, and wear and tear of plant, would add about $12.00 an acre to the cost of irrigation, an expenditure that would not be returned by ordinary field crops, although fruit and vegetables would give large returns on this amount of money. Second hand engines can be purchased for about $300.00, and they would do very well for the ordinary farmer, but not at an Agricultural College.

Gasoline engine: A gasoline engine rated at 18 H.P. may be purchased for $300.00. Such an engine would probably not give more than 18 H.P., for gasoline engines do not come up to their rating. The system would be the same as for steam engine, and the cost of the system would be $1,808.00. The operating expenses are less, however, for the engine requires no engineer, and the fuel costs but 1 cent per H. P. per hour. Thus it would cost per acre, for one irrigation, $.45, or $1.80 per season. The interest and wear and tear would also be less than for the steam system, being about $8.50 per season. All that has been said about the general utility of the steam engine is true of the gasoline engine, with the exception that the latter is not so well adapted for transportation.

Wind power: Special wind mills have been produced in the last few years that are especially adapted for irrigation. Of course with this system a large reservoir is necessary, and the water must not be too far below the surface. Where there is plenty of wind this is the least expensive of all systems. Many farmers in the west are now using wind power, one of whom, Mr. S. J. Koch, of Hershey, Nebraska, states that he is irrigating 15 acres of orchard, alfalfa and potatoes with one 16 foot mill, an 8 inch pump, and a 40 foot well. He has a resorvoir of one-half acre. The total cost was $225.00.

In our case, to be sure to always have plenty of water, it is thought best to have two separate wells, one at each side of the reservoir, and a pump and wind mill at each well. Two wells may be dug 30 feet deep, and two 14 foot aermotors, 40 foot towers, with special irrigation pumps can be erected and put in running order for $400.00. A square reservoir covering one acre, and capable of holding 7 feet of water, can be dug, well puddled with clay and made to hold water for $200.00. And the flume with a short piece of 8 inch pipe will cost $200.00. Thus this system can be put in operation for $800.00, which is twice what it would cost if there was a clay subsoil, and if it were possible to have a ditch instead of a flume across the field. The reservoir has been made 50% larger than necessary because of the great loss from seepage on such a porous soil; and for the same reason two 14 foot mills have been used instead of one 16 foot mill.

Because of the lay of the ground the wells and the reservoir would necessarily need to be just over the fence in field #9. The clay would have to be hauled some distance, and for that reason $150.00 was allowed in the estimate for clay. To cement the reservoir would cost over $1,000.00, which makes that impracticable. The only running expense of this plant would be the services of one man while the water was running, or for two days each irrigation; or about $.14 per irrigation per acre, or $.56 per season. The interest and wear and tear would be $4.70 per acre.

Comparison of the expense of the different systems.

	First cost.	Interest, wear and tear, on first cost per acre.	Operative expenses per acre.	Cost per acre per year.
Steam- - - - -	$1,858.00	$11.50	$3.60	$15.10
Gasoline- - - -	1,358.00	8.00	1.80	9.80
Wind- - - - - -	800.00	4.70	.56	5.26

It will thus be seen that wind power is by far the more economical of the three, costing but little over half the cost of gasoline, and one-third the cost of steam. Therefore were I to put the system in operation wind would be the power that I would choose. However, in a larger system the cost of steam and gasoline plants would be largely reduced.

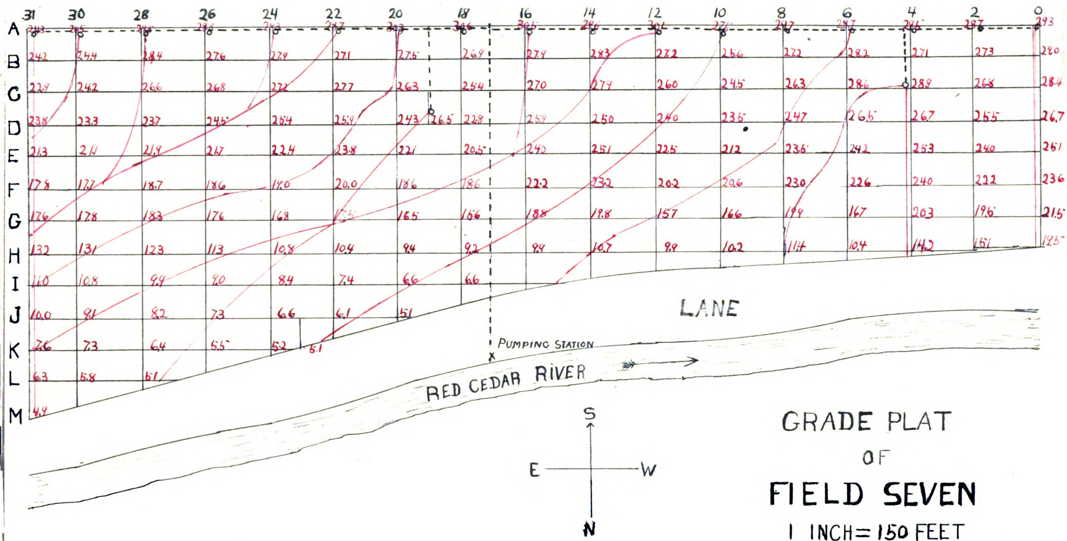
The reservoir: The reservoir would be made by scraping off the surface soil and piling it up so as to enclose an area 203 feet on a side, with an embankment 10 feet high. The dirt will settle so that the embankment will finally be but 8 feet high. Haul in clay and cover the bottom with a layer, roll this, turn in water and wet, then turn in horses and puddle until the reservoir is nearly water tight. Grass seed should be sown on the embankment, and booms stretched across to prevent wave action. The reservoir must never be allowed to stand empty, for the clay will dry and crack, thas necessitating re-puddling.

The flume: The flume should be made of two inch hemlock planks, 1 foot wide, nailed together, tarred on the inside and painted on the out side. It highest point, of course, should be at the reservoir, and from that point it should gradually slope to the east and west. At no place should it touch the ground, but it must rest on horses or blocks. Three inch holes can be made at numerous places along the side, to be closed with small sliding gates. The reason for using a flume instead of a five inch pipe is that it can be put in for one-fifth the cost of the pipe. A cheaper flume could be made from inch boards, but it would not be so durable, and would be likely to warp.

Running of the water:

Because of the lay of the field and the steepness of the grade at some points, the water will have to be run through irregularly curved furrows. Such furrows are represented on the plat by red lines, and they may be made by starting at the lower end of the furrow, and plowing toward the higher end, thus throwing the soil to the down-hill side. Those represented on the map are intended to be suggestive rather than arbitrary. The water may be run through the furrow for a distance, then dammed with a shovel-full of dirt and caused to overflow and run between the rows of corn, potatoes, etc., until they have received sufficient. Then the furrow may be again dammed farther down, and the operation repeated. A number of furrows may be running water at the same time. After an irrigation the field must be cultivated,- this will also re-fill the furrows.

The red figures on the plat indicate the height of the different portions of the field.


31 30 28 26 24 22 20 18 16 14 12 10 8 6 4 2 0
A B C D E F G H I J K L M
LANE
PUMPING STATION
RED CEDAR RIVER
S
E
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N
GRADE PLAT
OF
FIELD SEVEN
1 INCH=150 FEET