FUTURE OF SUB-SURFACE IRRIGATION:

INFLUENCE ON COTTON YIELDS AND QUALITY

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Four years ago, under the auspices of the Water Resource Research Institute, Professor Hanson and I initiated the first cooperative study on irrigation and fertility at this station as it affects growth, development, yields, and quality of cotton. Our choice of irrigation methods and rates have been reported by Hanson. He has discussed the installation, operation, and maintenance of the system and now let us discuss the effects upon yield and quality of cotton produced.

First, it is best to point out that no crop, commonly used by man, grows at its optimum or anywhere near optimum genetic potential when it is stressed for either nutrient, water, or any of the other factors for growth. In spite of all the problems that we have encountered in the past four seasons as pointed out in the previous paper by Hanson, we have effectively increased yields, and we have maintained quality of the product produced. There are potentials in the use of this system that have not yet been touched, some of which I hope to mention later. There is only one system of irrigation that I know of in the world that equals the potential of this system. It is a trickle irrigation system that is being used by the Israelis in part of the desert region that they are having to put under cultivation. Some combination of these two systems working together could show us possibly even further water savings from the standpoint of increasing the efficiency in the use of our water for agricultural production.

Buildup of salt in our system as mentioned by Hanson has been remarkably low over the years of operation, the final year's data are presently being analyzed. This salt buildup was checked by patterned sampling across the rows of crop at the end of each growing season in a manner worked out by Dr. Harold Dregne and myself. The work of sampling and analysis for salt was accomplished by one of Dr. Dregne's graduate students. These results and those from trickle irrigation in Israel are quite similar and both indicate that we can use waters of relatively poor quality for crop production without obtaining a large salt buildup for a relatively long period of time. I have not put an actual number of years on this salt buildup but it is my opinion that occasionally some leaching will be necessary to remove excess salts. The frequency of such leaching in the sub-surface irrigation system where surface evaporation is negligible will have to be determined over a long period of time. It is highly possible that this system through maintenance of

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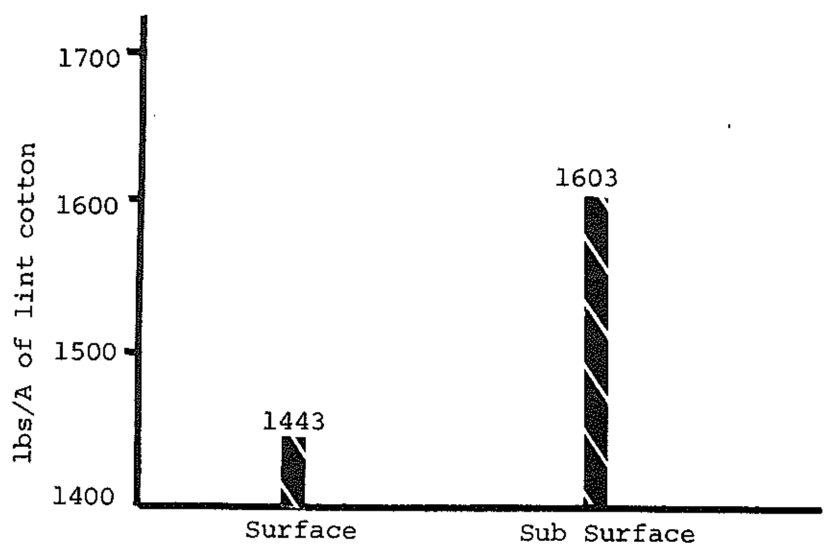


Figure 1. Lint cotton yields per acre for methods of irrigation

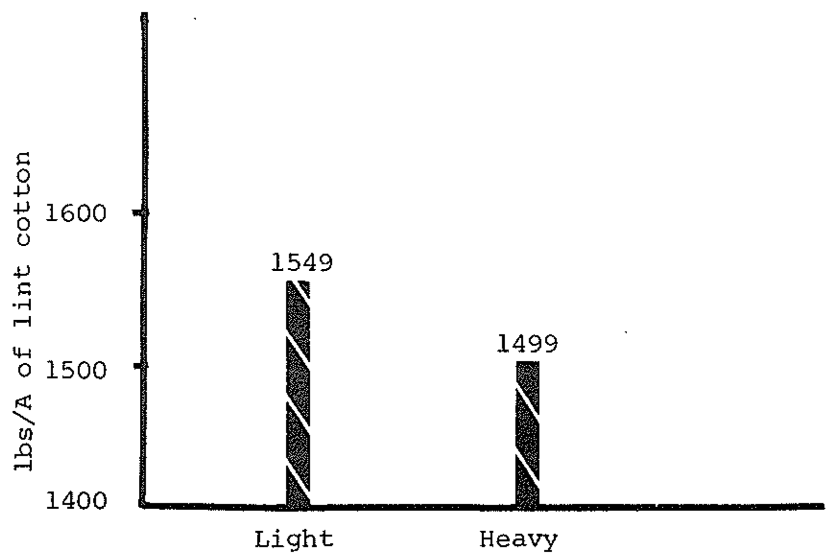


Figure 2. Lint cotton yields per acre for rates of irrigation

relatively constant low hydraulic tensions in the root zone of the plant may allow for a much more precise evaluation of detrimental salt concentrations and specific salt effects upon plant growth, development, and yield. On the irrigation experiment reported here, we have superimposed five fertility levels utilizing that fertility level in the field as a check and imposing a 4:1:1 NPK starting at 120 pounds of nitrogen, then going to 160, 200, 240 and 480 with the comparable ratios of phosphorus and potassium as the elements.[1] These fertilizers were sidedressed to the plant, one-half applied at planting and one-half applied at the time of first fruit forms. The soils from each plot were sampled for fertility analysis because this, as far as my part of it is concerned, must be taken into account when we evaluate the use of water. Over the years, we have gone back on the same plot every year with the same treatment. This has resulted in some buildup of fertility within these plots which has maintained an increased yield. Over the three-year period, we have had one relatively good year, we've had two relatively poor years, one of which was very poor from the standpoint of the normal climatic pattern. One thing that we have observed throughout the experiment is that on the average the maintenance of a continuous water level within the soil from the standpoint of the sub-surface system has given us from observation some slight increase in the temperature of the soil. This has meant to us on the average for the three years as much as two days earlier emergence of the cotton crop. It has meant that our fruit has set earlier and that the crop matured earlier. We picked what the geneticists have put in the crop for us to pick.

Here in the first figure we can see the effect that the method of irrigation had on lint cotton yield, these figures being the average for two years. I did not average in the raw data from the third year yield. If they are averaged in, however, it will only drop this difference slightly, with respect to the lint cotton yield. Here you see a difference of 160 pounds of lint cotton per acre in favor of the sub-surface system of irrigation. This, I believe, can be attributed to a continuous feeding where effects of detrimental changes in temperature in the root zone are at a minimum. The plant exhibits no great expenditure of energy for the uptake of water or nutrients. Therefore, the energy could be used for growth, and for maturing out the crop.

In figure 2 the differences we had between the light and the heavy irrigation rates can be seen. You note that heavy irrigation rates are not needed for good cotton yields. We had a fifty-pound differential in yield of lint cotton in favor of the light irrigation system -- the one that was adequate to keep the plant from showing any evidence of stress from moisture. This supports previous work by Hanson on effects of frequent light irrigations for crop production.

[1]To convert P and K to the oxide base (P_2O_5 and K_2O) multiply the pounds of element by 2.27 and 1.17 respectively.

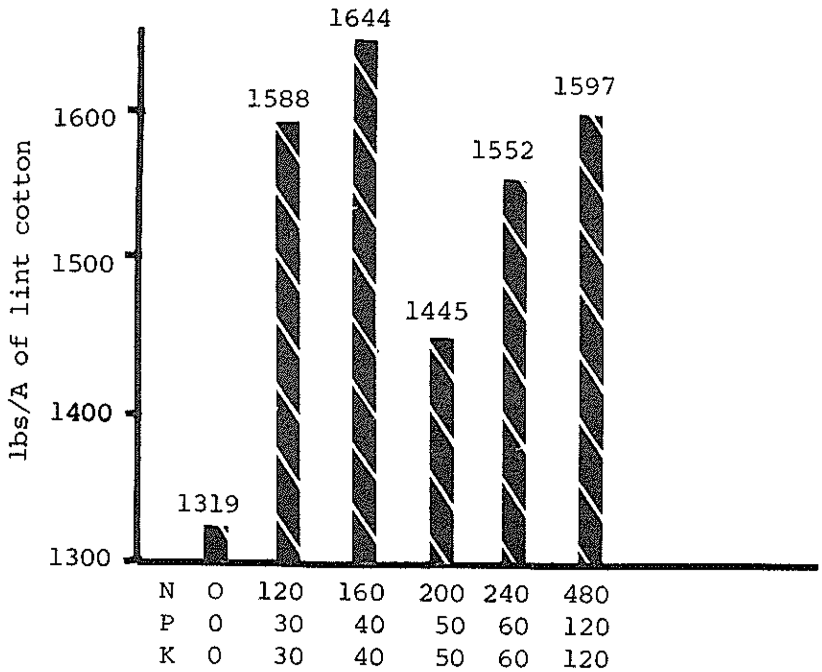


Figure 3. Lint cotton yield per acre for 6 fertility levels

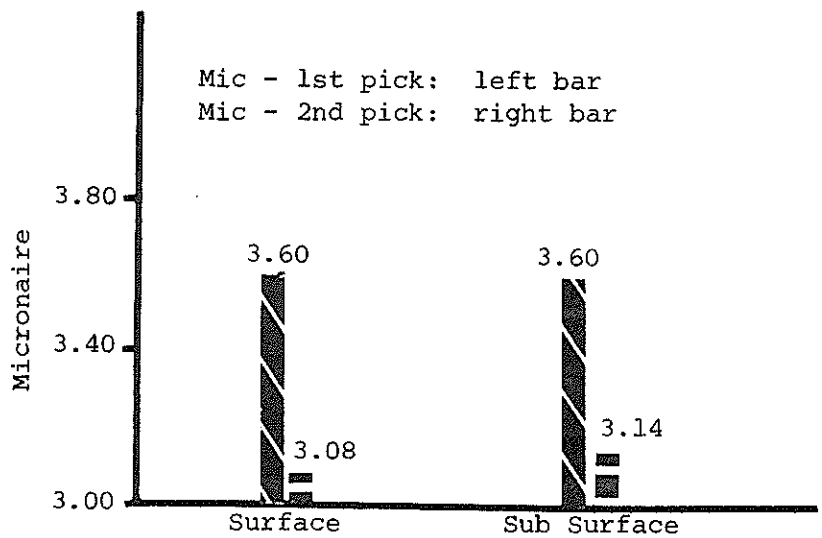


Figure 4. Micronaire values for methods of irrigation

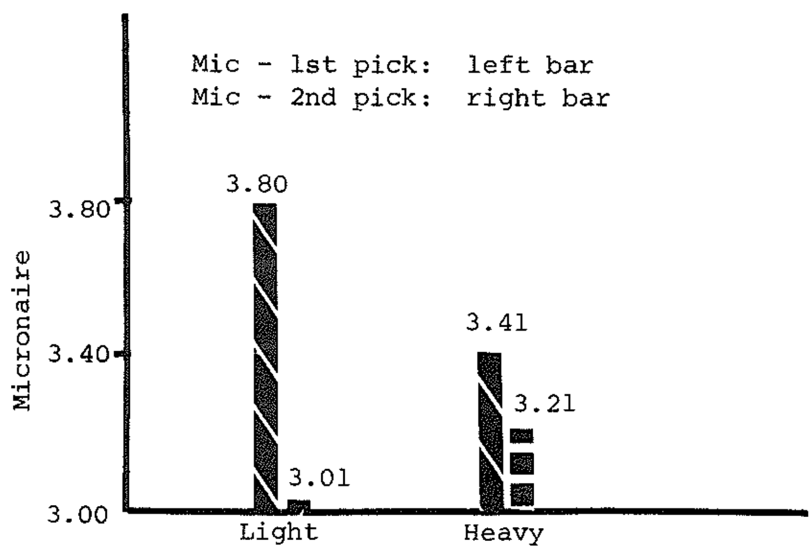


Figure 5. Micronaire values for rates of irrigation

One point here is that my use of the term "stress" is not limited to a deficiency. An excess of anything, water, nutrient, or any other factor affecting growth, can be as much of a stress upon the plant as the lack of that particular factor. The effect of low stress as indicated by this yield was shown in the plant growth during the season.

Since there was no interaction between fertility levels and irrigation methods and levels as determined in the individual statistical analyses as yet, the fertility levels have been separated out. In Figure 3 it can be seen that there is an increase in yield with increasing fertility levels. You will note that there is a 325 pound of lint cotton yield increase from the check, or no fertilizer application, to the rate of 160:40:40 of NPK per acre. This is a rate that has stood out in over ten years of fertility rate studies on cotton and the following drop that we note in yield with recovery at the higher rate is a common thing. I have no explanation as to why this occurs, I wish I did. Some day when we have a couple more good graduate students, maybe it will be possible to find out exactly what is happening in the system at this point. These yields are good yields as we can see that we are getting approximately three bales of lint cotton. These yields are especially good since these were occurring at the same time that the state average yield of lint cotton was decreasing rather rapidly and steadily. We have maintained and increased our yield of cotton by proper use of fertilizers and water. Either one, if improperly used, will give us poor yields and poor results. Good yields are what we want, but at the same time we want a product that is marketable. Therefore, we must look at the quality of the crop produced.

As one knows who has worked with cotton, the micronaire value for the cotton fiber is an estimate of maturity and fineness of the cotton produced within a variety of cotton. In other words, it is a measure of quality of product. So, I have restricted the presentation for this paper to the micronaire values. In Figure 4 we can see that the method of irrigation had no effect on the first picked cotton quality. The first picked cotton quality turned out a 3.6 micronaire value. In the second pick, you will note that the surface irrigated cotton dropped slightly lower than did the sub-surface irrigated cotton, and statistically it does not show a difference. The potential for better micronaire on sub-surface irrigated cotton is indicated.

A somewhat different effect is seen, Figure 5, with respect to rates of irrigation water applied. From the standpoint of the rates of water applied, you noted that we only needed the light rate from the standpoint of yield. We only need the light rate from the standpoint of quality of the fiber produced. Here we have an average micronaire for the first picked cotton in the light irrigation treatment of 3.8. This is a good quality cotton. We note that there is a very decided drop, however, into the second pick cotton

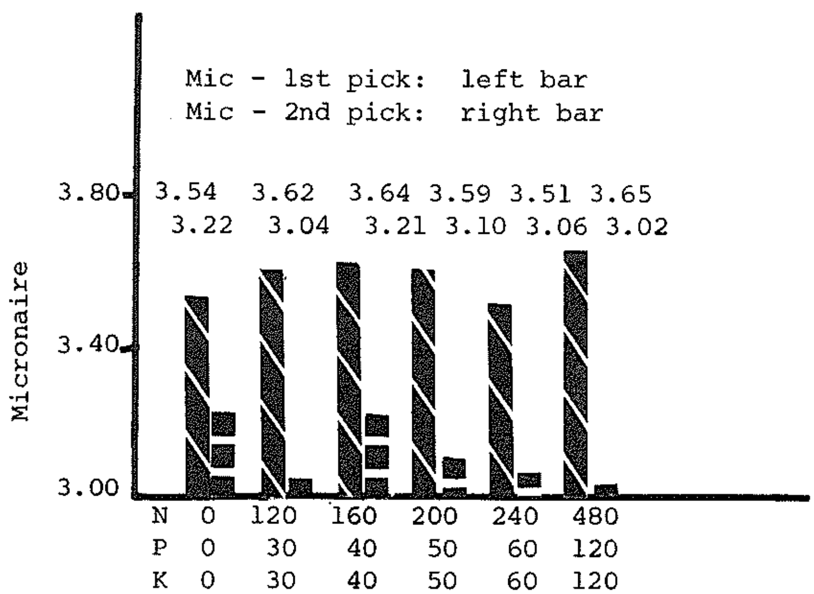
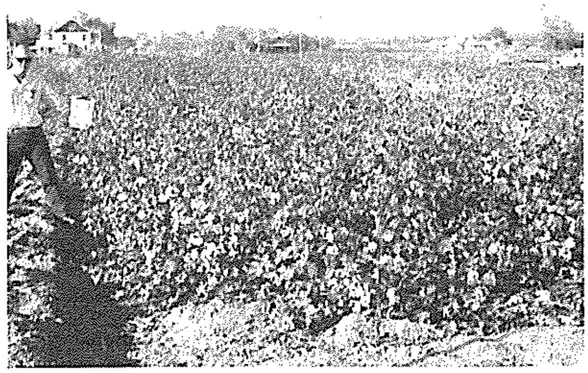


Figure 6. Micronaire values for 6 fertility levels



(a) Surface irrigated cotton that is not open well.

(b) Subsurface irrigated cotton that is well opened for first pick.

Figure 7. Effect of irrigation method upon open cotton, October 17, 1967.

where the micronaire value goes down to almost 3.0. There is one thing, however, that I would like to point out to you. Practically all of the cotton on this particular treatment was picked at the first pick. We picked less than twenty percent of our cotton in the second pick. So, therefore, we still had a real good marketable cotton crop. On the heavy irrigation treatment, micronaire values are poorer from the standpoint of the light versus the heavy on the first pick. It did not drop as much on the second. But we picked more cotton on the second pick. This indicates less crop maturity since more cotton was picked later in the season and a less acceptable crop for the market place as indicated by the lower crop micronaire value.

Now, with respect to fertility, we can see in Figure 6 that there is very little difference in the first picked cotton micronaire values. However, statistically, there is a difference between the 120, 160, and 480 levels and the other three levels of fertility. In the second pick cotton, you will note that the check, or no fertilizer treatment, and the 160 pound rate of nigrogen coupled with phosphorus and potassium gave us the best second pick micronaire cotton. These rates had the highest first pick yields and the best quality of cotton. Of course, I would prefer that which we got off the 160:40:40 NPK simply because of the fact that we got the best yields as well as the best micronaire values for the crop. I would not sacrifice the yield to obtain the micronaire value on the second pick crop on the checks. What this comes down to as far as we can see within our work, is the fact that if we utilize the water on the basis of consumptive use at the light irrigation rate, which we have proven can be done in the third year of experimentation without any surface irrigation water application, and with the proper fertility, we get a cotton crop that has good yield and good quality for the market place.

The surface irrigated cotton shown in Figure 7a is not open too well, it is late. These pictures were made on October 17.

Figure 7b shows the sub-surface irrigated plots. Practically all of the cotton opened for the first picking. We get back that which the breeder has put in the crop, if we manage our water and our soil with respect to fertility so that we can have an opportunity for the factors of the normal environment other than these two to be effective. With this combination of factors, we can obtain our yields and our quality while we are saving water and using water that we otherwise could not utilize.

The potential of saving of water in these studies ranges from 25 to 30 percent plus as indicated in the data for the first two years and confirmed in the third year of operation. As to the future of this particular system, we see many uses. Professor Hanson, at the end of his paper, mentioned a few. There are other potentials that we have not touched. There is one definitely that I feel that we must think of and have work on and that is the temperature effect. The effect of temperature upon crop growth, development, and yield is by far one of the greatest that we know. If we can reduce the fluctuations with respect to soil temperatures, by the maintenance of high moisture without detrimental effects upon aeration, or by the introduction of warm waters within the soil system, we cannot only further increase our yield but we should have a much greater effect upon the favorable quality of the product produced than we have yet shown. This should be effective because of a more constant rate of both water and nutrient uptake which should give a more nearly optimum condition for growth and development of the crop. This becomes even more important when coupled with feeding the fertilizer through these lines in relation to the uptake potential of the plant, day by day, the same as for the water. Higher yields with less amounts of fertilizer then become common because of an increase in efficiency in use of water and fertilizers greater than we have ever imagined.