The value of irrigation in sweet potato production in Louisiana

Teme P. Hernandez

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THE VALUE OF IRRIGATION
IN SWEET POTATO PRODUCTION
IN LOUISIANA

Teme P. Hernandez, Travis P. Hernandez,
Julian C. Miller and Lloyd G. Jones

Louisiana State University and Agricultural and Mechanical College
Agricultural Experiment Station  Doyle Chambers, Director
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The Value of Irrigation
In Sweet Potato Production in Louisiana

TEME P. HERNANDEZ, TRAVIS P. HERNANDEZ, JULIAN C. MILLER, AND LLOYD G. JONES

INTRODUCTION AND LITERATURE REVIEW

Although irrigation has been an established practice in some parts of the country, it is comparatively new on sweet potato production in Louisiana. Irrigation to supplement rainfall is necessary in most years to obtain highest yields. Unless soil moisture is adequate to meet the needs of the sweet potato plants, many of the recommended practices, such as better seed selection, use of improved varieties, proper fertilization, and others, are of little advantage.

Bowers et al. (1) reported that the rainfall distribution in Arkansas was such that the use of irrigation would generally increase yields of sweet potatoes. They reported a response to irrigation water with each of several sweet potato varieties used in their study. Ware and Johnson (9) found that the use of irrigation would improve the grade and quality and produce higher yields of marketable roots. Hernandez et al. (2, 3) reported an increase in yields of marketable sweet potatoes from irrigation; however, very high soil moisture levels at certain stages of growth caused the plants to become excessively vegetative at the expense of root set and growth.

Lambeth (5, 6) found that sweet potatoes require approximately 18 inches of water during the growing season in Missouri for maximum yields. The sweet potato crop depleted the soil moisture at a rate of 0.15 to 0.2 inch per day during July and August. He suggested that irrigation of a fine sandy loam soil should commence while the soil moisture in the root zone is still greater than 25 percent, possibly 40 to 50 percent, of field capacity.

Peterson (7) reported that the application of 1 inch of water at weekly intervals on sandy soil gave the best sweet potato production.

Sweet potatoes irrigated whenever the available soil moisture fell to 20 percent of the total available capacity were reported by Jones (4) to produce as high yields of U.S. No. 1 grade sweet potatoes as those irrigated at higher levels of soil moisture.

Climatological data for Winnbоро, Louisiana, from 1931 through 1956, show an average annual rainfall of 53.19 inches. The monthly averages for the same period show that June, August, September, and October are low, with average value of 3.99, 2.99, 2.71, and 2.05 inches, respectively. These same months represent periods of high water requirement by sweet potatoes grown under Louisiana conditions.

1Italic numbers in parentheses refer to Literature Cited, page 15.
Irrigation studies were conducted on a Richland silt loam soil at the Sweet Potato Research Center, Chase, Louisiana, for 4 years, 1953-1956, to determine the effects of supplemental irrigation on sweet potato production.

EXPERIMENTAL METHODS AND RESULTS

Irrigation System

Irrigation water was supplied either as a furrow application or with a sprinkler system. The Richland silt loam soil used had an infiltration rate of 0.5 inch of water per hour. The sprinkler system was designed to irrigate 40 acres in a 10-day period when irrigating 10 hours per day and applying 2.5 inches of water for each setting of 2 acres. A total of 720 feet of lateral 4-inch lines with 36 sprinkler nozzles was needed to cover 2 acres. Each nozzle delivered 12.5 gallons per minute, and the nozzles were spaced 40 feet x 60 feet apart. There were 700 feet of 5-inch main water line. This whole system or some part of it or furrow irrigation was used on the experimental plots during this 4-year period.

The irrigation water was pumped from a well by means of a 15-horsepower electric motor.

Methods of Irrigation

The method of applying irrigation water to the soil had no effect on the growth of the sweet potato plants as long as a continuous supply of soil moisture was available to the plants and a favorable environment, such as good soil aeration, was maintained. The furrow method of irrigation was very satisfactory on the level land used in some of this work. It was undesirable to flood over the top of the rows, especially if the water was allowed to remain for any length of time. In some cases low spots in the field would collect and hold water, causing waterlogging and subsequent damage to the plants.

The sprinkler irrigation system provided an accurate and uniform application when used on days with low wind velocity. Irrigation pipes, however, were difficult to move immediately after an irrigation because of muddy field conditions.

Soil Moisture*

The physical analysis of the Richland silt loam soil showed that the field capacity of this soil was 19.5 percent on an oven-dry weight basis and the wilting point was 6.5 percent. Since the water held in the soil between the field capacity and the wilting point is available to the plant, this is usually called “available water.” In this case, the available water amounted to 13.0 percent.

In these experiments the soil moisture samples were obtained in the

*The determinations of the water holding capacity and percent available moisture in this Richland silt loam soil were made by Dr. W. H. Patrick, Jr., Agronomy Department, Louisiana State University.
topsoil, the upper 10-inch layer of soil, and in the subsoil, the 10-
to 18-inch layer of soil. The soil moisture on all of the samples was
determined in duplicate on an oven-dry weight basis.

Analyses of soil samples shown in Figures 2 through 6 show that
some of the samples were below zero percent available soil moisture;
however, some sweet potato feed roots were apparently absorbing some
water from a zone deeper than that sampled, and the plants were able
to obtain enough water from that source to survive.

**Water Requirements of Sweet Potato Plants**

The water requirement for high fleshy root production varied during
the growing season. Usually sweet potato transplants have little or no
feed (or fibrous) roots at the time of planting. If the soil contains
available soil moisture with soil temperatures above 70° F. in the top-
soil where the feed roots develop first, the root system grows rapidly.
The feed roots do not develop readily when the topsoil moisture content
is very low or near the permanent wilting point.

During the 4-year period of this work, sweet potatoes transplanted
in the early spring (April or May) had sufficient soil moisture from
rainfall to get well established and make rapid growth when the soil
temperatures were above 70° F. However, sweet potatoes transplanted
in June needed supplemental irrigation 3 out of 4 years to replenish
the soil moisture around the limited root system, even though the re-
mainder of the soil in some cases contained readily available moisture.

A saturated soil also had adverse effects on feed root development,
especially when the soil temperature was below 70° F.

The periods of highest water requirement by the sweet potato plants
were in July, August, and September. At that time the plants had an
extensive feed root system and leaf area. The amount of irrigation
water needed to produce a good sweet potato crop varied from year to
year, depending upon the rainfall, temperature, relative humidity, wind
velocity, etc.

In a Richland silt loam soil over a 4-year period the daily water
requirements varied from 0.1 inch per day during the early part of the
growing season to 0.25 inch per day during the middle or latter part of
the growing season.

**Temperature and Relative Humidity**

The means for 2-day periods of the high and low temperatures and
relative humidities for part of the growing season of 1954 are shown in
Figure 1. For 1954, 1955, and 1956 the temperature and relative humidity
were continuously recorded on a hygrothermograph. In general, the
relative humidity varied inversely with the temperature. Each year
the relative humidity dropped very low at midday or shortly thereafter
in the last part of June, July, August, September, and October. Highest
temperatures were also recorded for the same months. Strong winds
were present periodically during these months. For each year there was a trend in relative humidity and temperature similar to that shown in Figure 1.

**Rainfall Over a 4-Year Period (1953-56)**

The 4-year monthly rainfall for the major portion of each growing season at Chase and for each year at Winnsboro (5 miles north of Chase) is shown in Table 1. The rainfall shown for Chase was recorded approximately 1/16 mile from the test plots.

**TABLE 1.—Rainfall for 4 Years (1953 through 1956) at Winnsboro, La., and at Chase, La. (April through October)**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan.</td>
<td>3.94</td>
<td>4.96</td>
<td>5.65</td>
<td>2.21</td>
<td>2.21</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feb.</td>
<td>6.82</td>
<td>1.94</td>
<td>7.27</td>
<td>10.57</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mar.</td>
<td>7.01</td>
<td>3.14</td>
<td>2.57</td>
<td>4.57</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apr.</td>
<td>7.00</td>
<td>6.69</td>
<td>9.65</td>
<td>4.02</td>
<td>4.09</td>
<td>4.66</td>
<td></td>
<td></td>
</tr>
<tr>
<td>May</td>
<td>15.00</td>
<td>16.38</td>
<td>10.04</td>
<td>7.26</td>
<td>4.19</td>
<td>3.88</td>
<td></td>
<td></td>
</tr>
<tr>
<td>June</td>
<td>0.00</td>
<td>0.63</td>
<td>1.83</td>
<td>9.81</td>
<td>2.42</td>
<td>1.94</td>
<td></td>
<td></td>
</tr>
<tr>
<td>July</td>
<td>2.50</td>
<td>2.18</td>
<td>4.67</td>
<td>9.80</td>
<td>3.24</td>
<td>2.86</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aug.</td>
<td>1.80</td>
<td>1.06</td>
<td>1.26</td>
<td>1.90</td>
<td>5.00</td>
<td>5.83</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sept.</td>
<td>0.60</td>
<td>0.73</td>
<td>1.81</td>
<td>2.06</td>
<td>1.08</td>
<td>0.79</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oct.</td>
<td>0.92</td>
<td>0.92</td>
<td>1.61</td>
<td>1.00</td>
<td>1.86</td>
<td>1.93</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nov.</td>
<td>1.67</td>
<td>1.51</td>
<td>4.58</td>
<td>1.96</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dec.</td>
<td>8.38</td>
<td>2.89</td>
<td>2.80</td>
<td>9.24</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Annual Rainfall</td>
<td>56.41</td>
<td>39.68</td>
<td>62.34</td>
<td>50.44</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>
There was unequal distribution of rain within each year (Table 1). This was also true for total rainfall among the 4 years. The months showing the lowest average rainfall were June, August, September, and October. Rainfall was highest in the early part of the growing season, when the water requirement of the plants was lowest. Further, during the middle and latter part of the growing season, when the water requirement was highest, the amount of rainfall received was lowest, with some exception for the month of July.

Response of Sweet Potatoes to Different Soil Moisture Levels

The topsoil moisture in the irrigation test for 1954 is shown in Figure 2 and the topsoil and subsoil moisture for 1955 and 1956 is shown in Figures 3, 4, 5, and 6. The sweet potato yield data for 1953, 1954, 1955, and 1956 are given in Table 2. Rainfall data for each year are given in Table 1.

### TABLE 2.—Effects of Irrigation on the Yield of Sweet Potatoes

<table>
<thead>
<tr>
<th>Variety</th>
<th>Date Planted</th>
<th>Date Harvested</th>
<th>Irrigated Increase over Non-Irrigated</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Bushels</td>
</tr>
<tr>
<td>Earlyport</td>
<td>4/23/53</td>
<td>8/24/53</td>
<td>234.0</td>
</tr>
<tr>
<td>Goldrush</td>
<td>6/18/53</td>
<td>8/8/53</td>
<td>146.0</td>
</tr>
<tr>
<td>Earlyport</td>
<td>6/18/53</td>
<td>8/8/53</td>
<td>158.1</td>
</tr>
<tr>
<td>Goldrush</td>
<td>5/27/54</td>
<td>9/21/54</td>
<td>386.0</td>
</tr>
<tr>
<td>Goldrush</td>
<td>6/18/54</td>
<td>10/8/54</td>
<td>274.9</td>
</tr>
<tr>
<td>Goldrush</td>
<td>6/6/55</td>
<td>10/18/55</td>
<td>345.6</td>
</tr>
<tr>
<td>Unit I Porto Rico</td>
<td>5/7/56</td>
<td>10/14/56</td>
<td>359.0</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td></td>
<td>271.9</td>
</tr>
</tbody>
</table>

1The yield data were significantly higher for the irrigated treatment than for the nonirrigated treatment at the .01 level.

2Marketable roots were from 1½ inches to 3½ inches in diameter.

Results in 1953

Two irrigation tests were conducted in 1953. The Earlyport variety was used in the first test and Goldrush and Earlyport in the second. In the first test the Earlyport variety was transplanted on April 23 and harvested on August 24. There was unequal distribution of rainfall during the growing season, with an unusually large amount of rainfall in May, none in June, and little in August through October (Table 1). Earlyport plants transplanted on April 23 in the nonirrigated plots suffered from drought, especially in June, early July, and August. The irrigated plots were watered with approximately 1.5 inches of water per irrigation on June 17, July 7, and August 3. Soil moisture determinations were not made in this year. At the period that Earlyport was
beginning to set storage roots, the nonirrigated plots were very low in soil moisture. There were practically no roots set in the nonirrigated plots, while in the irrigated plots there was a good set of sweet potato roots. The irrigated plots produced 234 bushels of marketable sweet potatoes per acre as compared with 10 bushels per acre for the nonirrigated plots (Table 2). There was an increase in yield of 49.8 bushels for each acre-inch of irrigation water applied in this early test.

In the second test, using Goldrush variety transplanted on June 18 and harvested on October 8, the irrigated plots produced an average of 146 bushels per acre as compared with 80 bushels for the nonirrigated plots. In this test the irrigated plots received approximately 1 1/2 inches of water per irrigation on July 3 and 10 and on August 7 and 17. There was an increase of approximately 11 bushels of marketable sweet potatoes for each acre-inch of irrigation water used.

Earlyport in the second test received the same treatment as Goldrush, and it produced 158.1 bushels per acre on the irrigated plots compared with 95.8 bushels on the nonirrigated plots. Thus, Earlyport produced an average increase in yield of 10.4 bushels for each acre-inch of water applied.

Results in 1954

In 1954 two irrigation tests were conducted. One test, using the Goldrush variety, was transplanted on May 27 and harvested on September 21. All of the plots had the same soil moisture content at planting time. The first supplemental water on the irrigated treatment was given on June 17. Duplicate soil moisture samples in the topsoil and subsoil were taken in the irrigated and nonirrigated plots on June 26, and subsequent samples were taken at 3- to 6-day intervals. The percentage available moisture was determined for each treatment at each sampling period. As shown in Table 1, the rainfall at Chase was low in June, July, August, September, and October.

The soil moisture values for the top 10 inches of soil in both the irrigated and nonirrigated plots are shown in Figure 2. In the nonirrigated soil the moisture dropped below 20 percent available moisture and by July 20 it had declined to 5 percent available moisture. After July 10 there was very little rainfall. Light showers sometimes caused increases in the topsoil moisture but only for very short periods because of the high day temperatures, low relative humidities, and large leaf surface area of the plants. The irrigated plots were given six irrigations, using 1.5 to 2 inches of water per irrigation. The soil moisture (Figure 2) after each irrigation rose to approximately 82 to 100 percent available moisture. The irrigated plots produced 386.0 bushels of sweet potatoes per acre compared with 70.2 bushels on the nonirrigated plots. There was an increase in yield of 28.7 bushels for each acre-inch of irrigation water applied in this test.

A second test with Goldrush was transplanted on June 18 and harvested on October 8. Periodic soil moisture samples were taken on the
irrigated and nonirrigated plots. The soil moisture on the irrigated plots was maintained above 50 percent available moisture in the topsoil. The irrigated plots were given five irrigations, using 1 to 2 acre-inches of water on July 2 and 27, August 10 and 22, and September 2. The irrigated plots produced 274.9 bushels of marketable sweet potatoes compared with 110.2 bushels for the nonirrigated plots. This was a 25.3-bushel increase in yield per acre-inch of irrigation water used.

Results in 1955

Soil moisture for the topsoil and for the subsoil is shown in Figures 3 and 4, respectively, for irrigated and nonirrigated plots in the 1955 irrigation test. There were frequent rains from the middle of June through the middle of August. From July 15 through August 10 the topsoil moisture varied from 50 to 100 percent available moisture in the irrigated plots. The subsoil moisture remained above 60 percent available moisture from planting time until approximately August 25 (Figure 4). This test was transplanted with Goldrush on June 6 and harvested on October 18.

Little rain fell in late August, September, and October. During this period the topsoil moisture in the nonirrigated plots dropped below 12 percent available moisture (on August 22) and remained fairly low (Figure 3). The irrigated plots were watered on August 19 and September 8 with approximately 1.5 inches per irrigation. The irrigated plots produced 345.6 bushels of marketable sweet potatoes per acre compared with 283.5 bushels for the nonirrigated plots. There was an increase of 17.7 bushels per acre-inch of irrigation water used in this test.
Also in 1955, other plots of Goldrush and Unit I Porto Rico were transplanted on May 15 and on June 15. Regardless of the date of transplanting, the Unit I Porto Rico plants did not begin to set stc roots until after August 10. During July and early August the Unit I Porto Rico plants were still in the early stages of growth and development.
Porto Rico variety grew excessively vegetatively at the expense of sweet potato storage root formation. However, the Goldrush plants did not show the same response as Unit I Porto Rico to this high soil moisture condition, and the vines did not become highly vegetative. In July there were many days with heavy overcast of clouds. The Goldrush variety set roots earlier than Unit I Porto Rico, and comparative yield data under the same growing conditions showed that Goldrush produced 450 bushels of marketable roots per acre compared with 265 bushels for Unit I Porto Rico.

**Results in 1956**

Available water in soil moisture samples from the irrigated and nonirrigated test plots in 1956 is shown in Figures 5 and 6 for the topsoil and subsoil, respectively. There were frequent light showers throughout the growing season which caused sharp rises in soil moisture; however, the effects of these light rains were of short duration. This test was transplanted on May 7 and harvested on September 14. There was low rainfall in June and July, and especially in September and October (Table 1). The soil moisture remained above 40 percent of field capacity until approximately June 7, at which time the first irrigation was given to the irrigated plots. Rainfall on June 15 increased the topsoil moisture to 70 percent available moisture in the nonirrigated plots (Figure 5). However, by June 28 the topsoil moisture had dropped to a point of no available moisture. By this date the sweet potato plants in the irrigated and nonirrigated plots had made good vine growth and each plant had set from three to six storage roots. During the remainder of the growing season the plants in the irrigated plots were watered four more times. In July, August, and September the plants in the nonirrigated plots suffered from drought and showed yellowing of the

![FIGURE 5.—Available water in the top 10 inches of soil as related to irrigation and precipitation in 1956.](image-url)
leaves, wilting of plants, and lack of growth. The irrigated plots produced 359.0 bushels per acre compared with 175.6 bushels for the non-irrigated plots. This was an increase of 17.5 bushels per acre-inch of irrigation water used.

**DISCUSSION OF RESULTS**

Soil moisture control, even in humid areas like Louisiana, helps to eliminate one of the most costly and unpredictable farming hazards in sweet potato production. In these experiments the sweet potato irrigation plots required an average of approximately 0.10 inch of water per day during the first 5 to 6 weeks of growth, after which the water needed gradually increased until in midsummer it reached 0.25 inch per day. The water required for the sweet potatoes was dependent especially on the total leaf area, relative humidity, temperature, and wind.

Sweet potatoes transplanted in late April or May generally had sufficient natural soil moisture to develop a fibrous root system fast enough to supply the necessary water for normal plant growth. However, plants transplanted in June generally needed irrigation water to replenish the soil moisture around the limited root system even though the remainder of the soil contained readily available moisture. After 40 to 50 days of growth, sweet potatoes have an extensive feed root system and have begun to set fleshy roots. On the Richland silt loam soil in which these tests were conducted, a hardpan existed at a depth of approximately 10 inches. However, in plots that were irrigated this hardpan was not as firm, and a soil tube could easily be pushed through this layer. Good soil moisture allowed the feeder roots to easily penetrate this layer. A large number of feed roots were present in the
subsoil of the irrigated plots, but in the nonirrigated plots very few feed roots were present in this area. These conditions were present in 1953 and 1954 and to some degree in 1956.

At Chase, Louisiana, the periods of the highest water requirements by the crop are generally the periods of lowest rainfall (Table 1). These months are July, August, September, and October. The unequal distribution of rainfall causes frequent droughts during the growing season. Over a 4-year period, each acre-inch of irrigation water used produced an average increase of 23 bushels of marketable sweet potatoes.

The sweet potato plants grew very well vegetatively at a soil moisture content of 50 percent available moisture or above, and this is desirable until the vines cover the ground. After that time storage roots set, and their growth appeared to be greatest at less than 50 percent available moisture. Very high soil moisture conditions when the sweet potato roots are about to set can cause the plants to continue to grow excessively vegetatively at the expense of storage root formation. This condition occurred in a Richland silt loam soil in 1955.

The time when sweet potato storage roots are growing represents a period of high water need by the plants. It is very difficult to maintain a uniform soil moisture content even with an irrigation system because of high temperature, low humidity, and periodic high wind. These conditions cause rapid fluctuations in the topsoil moisture (Figures 2, 3, and 5). After sweet potato storage roots have set, soil moisture conditions at 50 percent available moisture or above have a tendency to produce storage roots that are rough in surface texture. However, if the storage roots develop under soil moisture conditions of 25 to 40 percent available moisture, the roots will grow more slowly but will be smoother and more uniform in shape and generally have a higher percentage of dry matter (8). The dry matter and total carotenoid contents of the sweet potato roots grown under irrigated conditions each year were slightly but consistently lower at harvest than in roots grown under nonirrigated conditions (8). These reductions are minor and have little economic significance.

Over a 4-year period the irrigated plots produced an average increase of 154 bushels of marketable sweet potatoes per acre over the non-irrigated plots.
SUMMARY

1. Supplemental irrigation water produced an average increase of 154 bushels of marketable sweet potato roots per acre, or an increase of approximately 23 bushels for each acre-inch of irrigation water used.

2. Sweet potatoes required an average of 0.10 acre-inch per day in the early part of the growing season. This gradually increased to as much as 0.25 acre-inch of water in midsummer, depending on stage of plant growth, temperature, humidity, wind, and other environmental factors.

3. High soil moisture levels over a period of several days—40 to 50 days after transplanting—can cause sweet potato plants of the Unit I Porto Rico variety to become excessively vegetative at the expense of storage root formation and growth.

4. Drought approximately 40 days after transplanting of sweet potatoes, allowing the soil moisture to drop below 20 percent for a few weeks before fleshy root set, caused the greatest reduction in yield. Droughts after five or more roots had set on each sweet potato plant were not as serious, provided precipitation occurred or water was applied later in the season to mature the roots.

5. In a Richland silt loam soil, sweet potatoes evidently make best storage root growth at approximately 25 to 50 percent available soil moisture.

6. With the use of irrigation, sweet potato plants can be planted whenever the plants are ready to move into the field. Very good stands of plants resulted under irrigation. This may also apply to transplanting machines using starter solution.

LITERATURE CITED


