Evaluation of a Drip Vs. Furrow Irrigated Cotton Production System

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Abstract

A newly installed subsurface drip system was compared to a conventional furrow-irrigated cotton production system in the Marana Valley in 2000. Regular measurements included soil moisture, flower tagging, general plant growth and development measurements, and lint yield. Results indicate that an increase in lint yield of approximately 250 lbs. lint/acre was obtained under the drip irrigation system. Approximately 1/3 less irrigation water was used under the drip irrigation system. Pounds of lint produced per acre-inch of water applied provide the most dramatic results. In the furrow-irrigated system approximately 25 lbs. of lint was produced per inch of water applied while the drip system ranged from 70-80.

Introduction

In desert agricultural production systems, water is by far the most limiting factor. Proper crop water relations are essential in optimizing cotton growth, development, and yield. Traditional methods of irrigation in Arizona and other irrigated regions of the cotton belt include flood or furrow irrigation. Other methods of delivering irrigation water to the crop have been successfully implemented in cotton production systems. One of these methods is subsurface drip irrigation. This method of water delivery can greatly enhance irrigation efficiency and the efficiency of fertilizer applications. Fertilizers are often applied through subsurface drip systems (fertigation) allowing for placement of the fertilizer directly in the rootzone. Fertigation also allows the fertilizer to be applied at the proper time to coincide with the demand of the crop.

A subsurface drip irrigation system has the capability of applying sufficient water to meet the evaporative demand of the crop on a daily basis. This promotes maximum growth while minimizing any stress resulting from an inadequate supply of soil moisture. Proper water management of a crop with subsurface drip prevents the development of anoxic conditions that can frequently occur to the crop directly after a furrow irrigation event, while minimizing the water stress that often occurs just prior to a furrow irrigation event. Therefore, with proper management, water stress can be minimized so that it does not become a limiting factor in achieving an optimum yield.

The objective of this project was to compare several aspects of a newly installed, 130-acre subsurface drip system to an adjacent 40-acre conventional furrow irrigated field.

Materials and Methods

The subsurface drip system was installed during the winter and early spring of 1999/2000 near Marana, AZ at approximately 2000 feet elevation. The furrow-irrigated field is a fairly uniform Pima silty clay loam soil. Approximately the east 2/3 of the drip field is classified as a Gila loam soil. The west 1/3 of the field is classified as a Vinton-Anthony sandy loam. The furrow-irrigated field was planted to Stoneville 474 on 18 April into moisture. The east 64 acres of the drip field were planted to Stoneville BXN 47 on 1 May with the remaining 66 acres planted to DPL 33B on the same day. The drip-irrigated field was dry planted and then watered up with the drip system. Irrigations were terminated during the first week of September for both fields.

To accomplish the soil moisture measurements made using a neutron probe, two access tubes were placed in both the furrow and drip irrigation fields. Measurements were made to a depth of 150 cm by 30 cm increments on approximately 3-day intervals from the beginning of June through mid-August. Neutron probe counts were converted to volumetric water content using a calibration curve specific to that probe and soil type.

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Flower tagging was conducted on approximately 3day intervals from the beginning of July (first bloom) to late April (just prior to cut-out). Fresh flowers were tagged in four separate, 3-m row segments in both the furrow and drip irrigated fields. Retained blooms were calculated by collecting the number of tags remaining on the plant after defoliation.

General plant measurements including; plant height, number of mainstem nodes, node of the first fruiting branch, number of aborted or missing fruit, nodes above the top fresh flower (NAWF), and petiole NO_3^--N levels were taken approximately once per week. From this data we are able to calculate percent fruit retention (FR), height (in.) to node ratio (HNR) and also monitor the nitrogen (N) status of the crop.

Leaf water potential readings using a leaf pressure chamber were taken periodically just prior to and just after furrow irrigation events in both the furrow and drip irrigated fields. Approximately 5 leaves were taken from each field for leaf water potential measurements.

Final lint yields were estimated by harvesting approximately 48 row blocks into modules. Final lint yield was estimated from local gin weights and turnout values for each module.

All of the parameters measured were referenced to back to stage of growth using heat units accumulated after planting (HUAP).

Results and Conclusions

Despite the fact that the furrow-irrigated field was planted approximately 10 days earlier, both crops were similar with respect to growth and development. Fruit retention and HNR estimates for both fields are shown in Figure 1. The drip-irrigated field had more vigorous crop growth as evidenced by the HNR graph in Figure 1. Fruit retention levels for the drip-irrigated field were consistently higher over the growing season. The increased FR was also observed with the flower tagging data (Figure 2). The drip-irrigated field retained a higher number of flowers early in the season and also later in the season (Figure 2).

Table 1 lists values for NAWF in both the drip and furrow-irrigated fields. These data demonstrate the fact that the furrow irrigated field progressed through cut-out more rapidly than did the drip-irrigated field. This is most likely due the improved water status of the plant in the drip-irrigated field, which alleviated significant water stress. Table 2 lists the petiole NO_3^--N levels for both the furrow and drip-irrigated fields. The drip-irrigated field appeared to maintain a higher level of N fertility than did the furrow-irrigated field. Both fields were fertilized in a similar manner receiving two applications of approximately 50 lbs. N/acre (100 lbs. N/acre total).

Soil moisture levels measured using a neutron probe are shown in Figures 3 and 4 for the furrow and drip-irrigated fields respectively. Figure 3 demonstrates the fluctuations in soil moisture that commonly occur under a furrow irrigated system leading to periods of stress before (dry conditions) and after (anoxic/saturated conditions) a furrow irrigation event. Figure 4 shows the more consistent soil moisture status that is common under drip-irrigated systems. This provides for a more stable environment of reduced stress and favorable water status for the crop.

Figure 5 shows the total amount of irrigation water applied to both the drip and furrow irrigated fields. On average, approximately 20-25 acre-inches of water/acre was applied during the season to the drip field. It should be noted here that this value does not include the water used to germinate the crop. An additional 3-5 acre-inches of water was used to wet the seed for germination. The furrow-irrigated crop required approximately 60 acre-inches of water. As with the drip field, this value does not include the pre-irrigation water required to prepare the field for planting.

Lint yields estimates for both varieties in the drip system and the furrow system are shown in Figure 6. Lint yields were very similar between the BXN 47 (drip) and the STV 474 (furrow). However, the DP 33B produced approximately 250 lbs. Lint/acre more in the drip than the Stoneville varieties in either system.

The most notable results are found in Figure 7. Water use efficiency (WUE) estimates were calculated as lbs. of lint produced per acre-inch of water applied. The furrow-irrigated system achieved a WUE of approximately 25 lbs. lint per acre-inch of water applied while the drip system achieved approximately 70-80.

Overall the drip system performed well for the first year despite the fact that many challenges were experienced in relation to the new system of irrigation and management that was employed. Continued research will be conducted with this new system examining both phosphorus (P) nutrition and variety evaluation in the 2001growing season.

Table 1. Nodes above the top fresh flower for both drip and furrow irrigated fields.

Drip		**Furrow**	
HUAP on Sample Date	**NAWF**	**HUAP on Sample Date**	**NAWF**
1500	11.0	1394	10.0
1677	9.5	1517	9.0
1840	8.5	1701	9.0
2340	5.0	1884	7.6
2550	3.0	2547	1.8

Table 2. Petiole NO_3^--N levels for both drip and furrow irrigated fields.

Drip		**Furrow**	
HUAP on Sample Date	**Petiole NO_3^--N (ppm)**	**HUAP on Sample Date**	**Petiole NO_3^--N (ppm)**
1310	21,000	1517	13,000
1500	17,000	1701	15,000
1677	14,000	1884	11,000
1840	15,000	2047	6,100

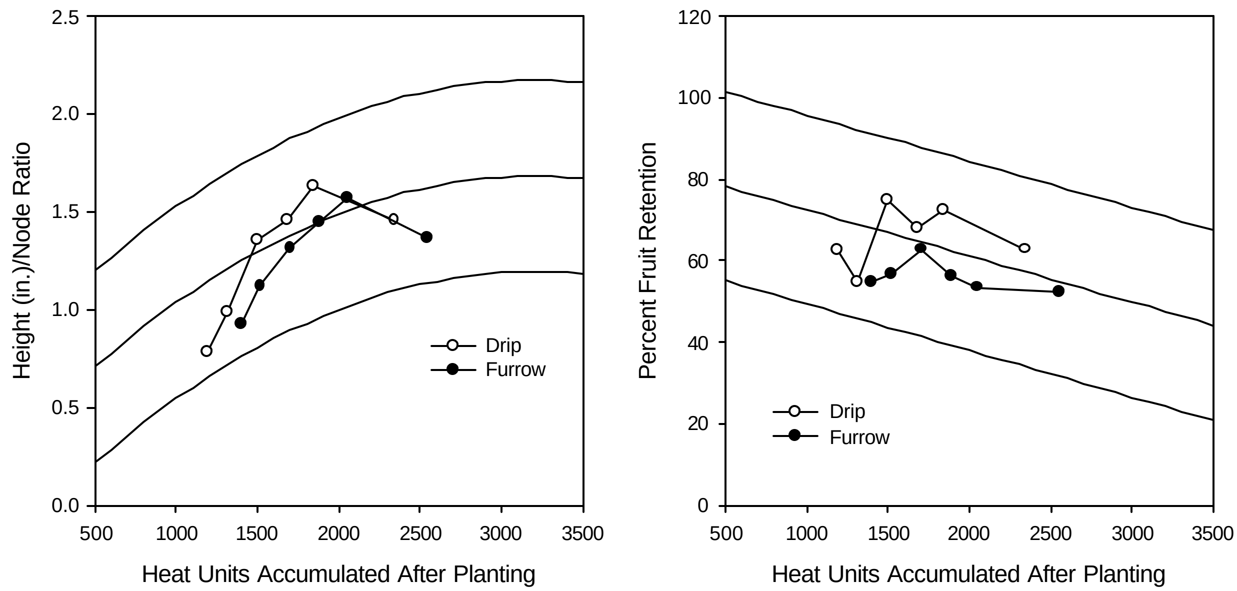

Figure 1. Height (in.)/node ratio and fruit retention estimates for both drip and furrow-irrigated fields.

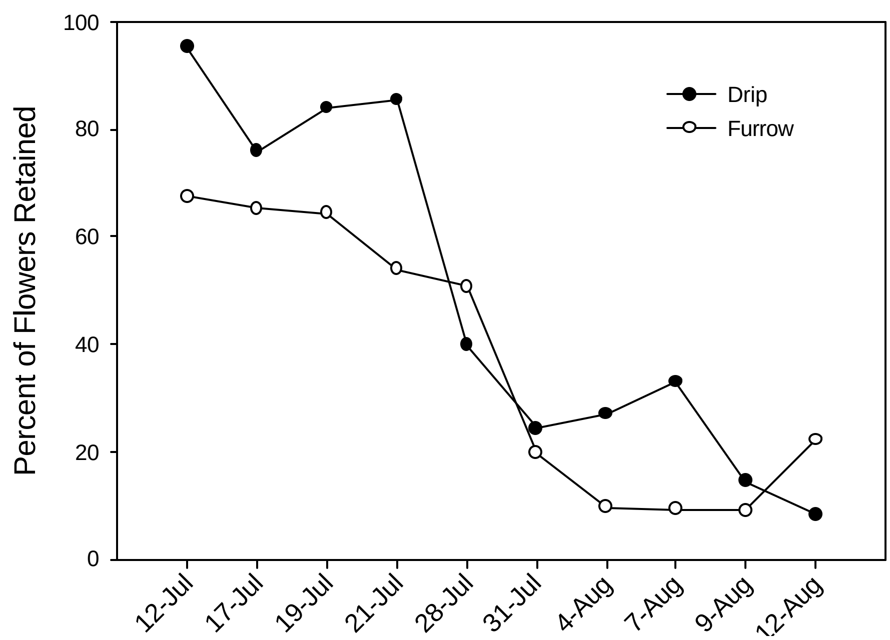

Figure 2. Flower tagging data illustrating the number of retained flowers for both the drip (BXN 47) and furrow irrigated (STV 474) fields.

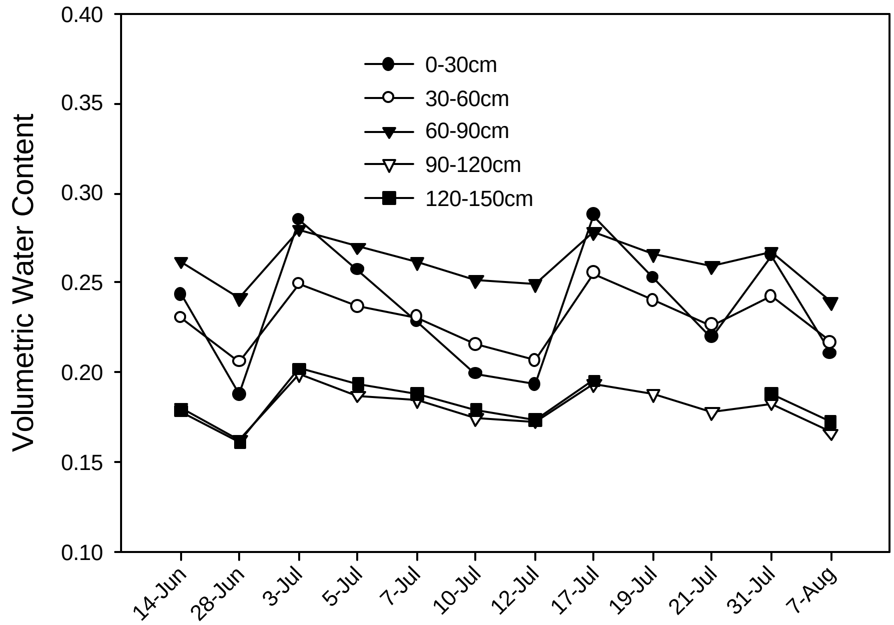

Figure 3. Volumetric water content measured with a neutron probe for the furrow-irrigated field to a depth of 150cm by 30 cm increments.

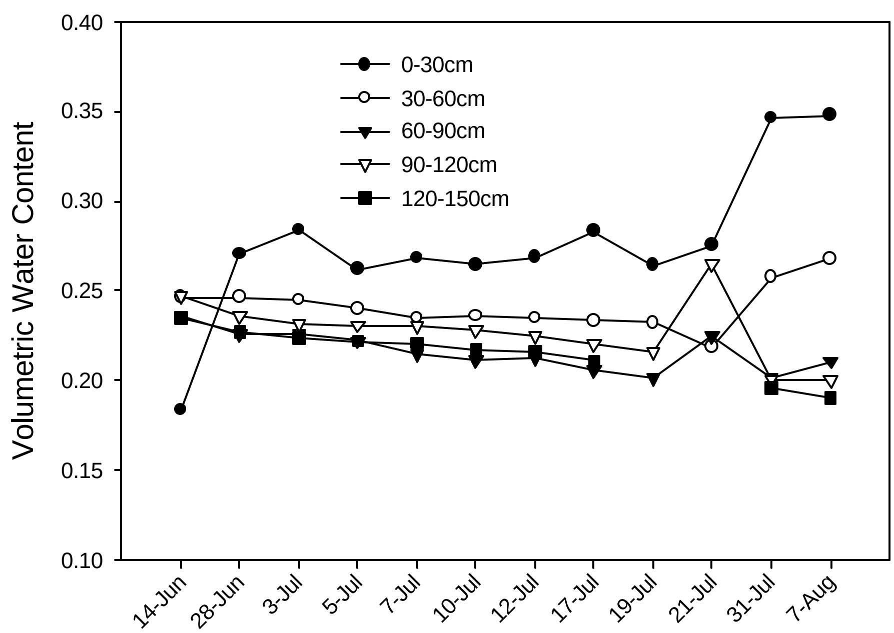

Figure 4. Volumetric water content measured with a neutron probe for the drip-irrigated field to a depth of 150cm by 30 cm increments.

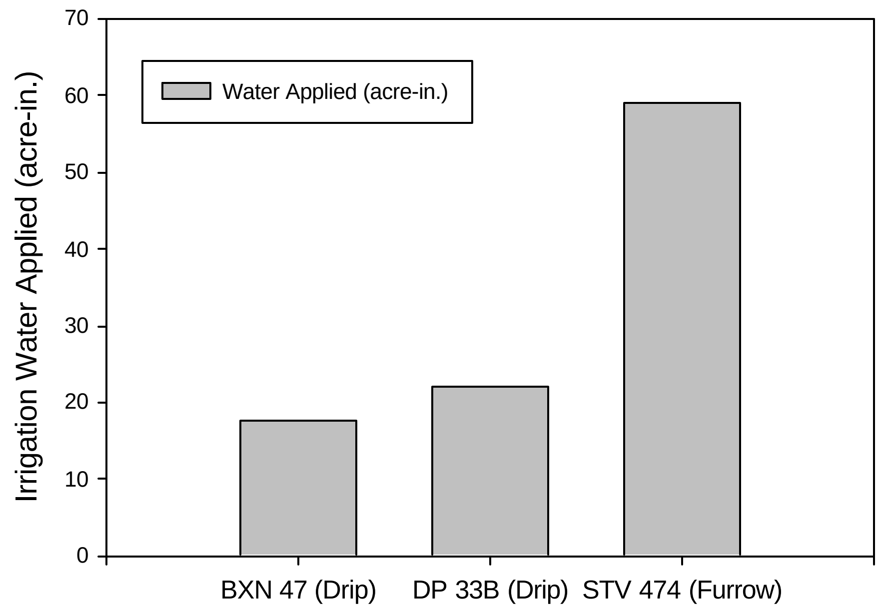

Figure 5. Total amount of irrigation water applied for both the drip (BXN 47 and DP 33B) and the furrow (STV 474) irrigated fields.

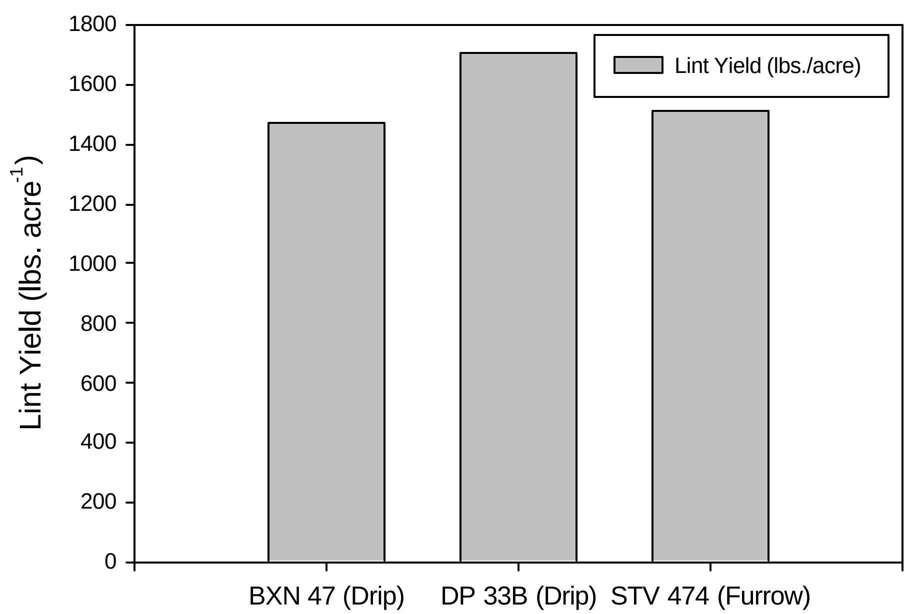

Figure 6. Lint yield estimates for both the drip (BXN 47 and DP 33B) and the furrow (STV 474) irrigated fields.

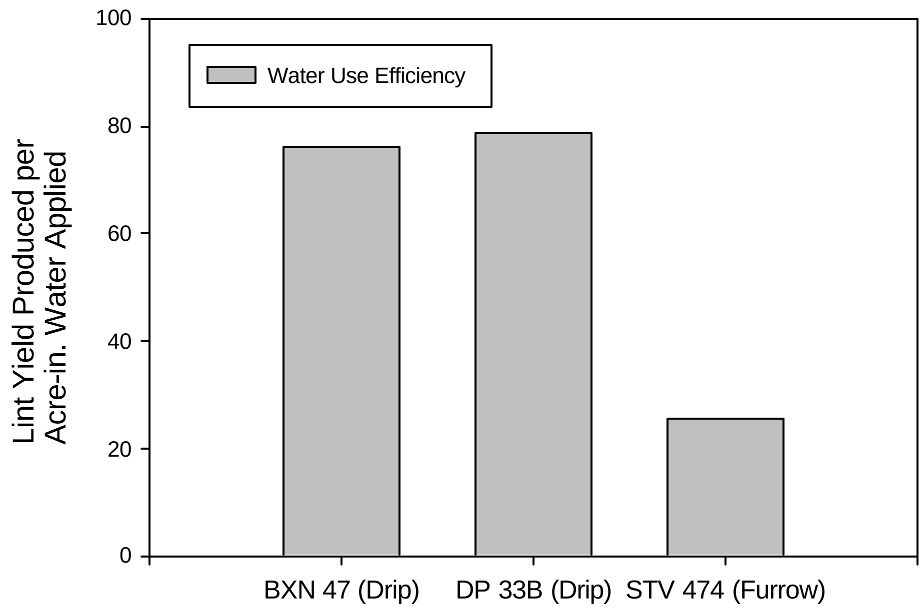

Figure 7. Water use efficiency expressed as lint yield produced per acre-in. of irrigation water applied for both the drip (BXN 47 and DP 33B) and the furrow (STV 474) irrigated fields.