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# Irrigating cotton with salty water and Subsurface Drip Irrigation

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**Abstract.** An experiment with a Subsurface Drip Irrigation system was planned on a Texas farm with salty water to develop design and management recommendations for SDI systems. The objectives of this study were: 1) Compare 0.20 and 0.30 m depth, and 1.02 and 2.03 m drip spacings when water is salty. 2) Determine if pre-season irrigation can be used to control the soil salinity level on the soil profile when deficit irrigation is practiced on SDI systems. The experiment consisted of a complete randomized experiment with 8 treatments and four replications, with a total of 32 plots. Lint yield, seed yield and total gross return resulted statistically higher for the 1.02-m than the 2.03-m drip spacing indicating higher yields for closer spacing. Lint yield and total gross return resulted statistically higher for the 0.3-m than the 0.2-m drip depth indicating higher yields for deeper drip depth, probably because of the higher soil evaporation of the shallower drip depth. The depth and the spacing of the drip tape did not have an effect on cotton quality as it was indicated for the loan value. There was no effect of the different pre-water treatments on lint yield, seed yield, loan value, and total gross return.

**Keywords.** Drip, subsurface irrigation, cotton, water management

## Introduction

Water is the main limited resource for the Texas Cotton production. Water aquifers are being depleted in many areas of the West, and farmers have adapted new agronomic practices to increase water use efficiency such as using narrower row spacing, to reduce tillage practices, to irrigate more frequently, to practice deficit irrigation, and to use center pivots and Subsurface Drip Irrigation (SDI) systems. The problem with SDI systems in arid and semi-arid areas of the West is that some salinity may occur above the tubing since there is no leaching, and leaching only will occur as the result of rain. The accumulation of salts can be a bigger problem during germination. Higher salinity can be found in the top 2 to 3 inches, and it may be influenced by the depth and spacing of the tape, and pre-seasonal irrigation. When irrigation is practiced under water limiting conditions salts will start to build up in the soil. Leaching the salts out of the root zone is the only way to control salinity. Pre-watering and refilling the soil profile before planting may leach the salts below the drip tape before planting. Salinity can produce reduction on cotton lint yield, and reduce the profitability of the system. Salty water exists in several regions and the degree of salinization also varies. In West Texas the salinity varies from one well to another and from location to location. For example although most of the water wells of the Saint Lawrence area have Electrical Conductivities (EC) of 1600 micromhos/cm, some wells have 4500 to 5800 micromhos/cm (3200 to 4200 ppm) and a Sodium Adsorption Ratio (SAR) of 6.3 to 7. In Coyonosa, Texas the water wells have an EC 3810 micromhos/cm (3250 ppm) and a SAR of 4. The water in the Pecos Research Station has an EC of 2680 to 3230 micromhos/cm (approximately 3000 ppm), but a SAR of 8 to 12. In El Paso where water comes from the Rio Grand River, the EC vary from 800 to 1000 ppm, and SAR varies seasonally and spatially. For example in the American dam located in the entry of El Paso the salinity concentrations and SAR vary from 3.0 in summer to 6.5 in winter. At the El Paso-Hudspeth county line the SAR varies from 4.2 to 11.6. In Hudspeth, which is downstream from El Paso City the SAR varies from 5.7 to 18. The increase of sodicity and salinity downstream of the river is due to the return flow and sewage discharges. The problems associated with salinity are complex, and some are related with the ratio between the salinity and the RAS of the water, and also due to permeability of the soil. In general, water that exceeds 3,000 micromhos/cm is considered unsuitable for irrigation for sensitive plants, if there is not good drainage in the soil. Although cotton is a very salt tolerant plant, it can still present difficulties during germination with salty water. During this stage is important to manage salinity and to have a good design of the irrigation system (Ayers and Wescot, 1976). SDI irrigation may be very effective at flushing salts out of the root zone, if the drip tape is properly placed (Tanji et al., 1996). The objectives of the study were 1) Compare 0.20 with 0.30-m drip depth, and 1.02-m with 2.03-m drip spacing and 2) to determine if pre-season irrigation can be used to control the soil salinity level on the soil profile when deficit irrigation is practiced on SDI systems.

**Material and methods**

A research plot irrigated with a SDI system was installed in Saint Lawrence on a cooperator farm where they have salty water to develop drip depth and drip spacing recommendations for SDI systems. The area is semi-arid and receives less than 400 mm of rainfall per year. The rainfall received during the growing season is presented in Table 1. The experiment consisted of a complete randomized experiment with 8 treatments and four replications, with a total of 32 plots. Each plot consisted of 4 cotton rows, 290 m long. The total irrigated area was 3.72 ha. Each treatment represented and area of 0.46 ha. The cotton rows were spaced every 1.02 m. The treatments were: 1) Every 1.02 m drip spacing – 0.20 m drip depth - 80% pre-irrigation; 2) Every 1.02 m drip spacing – 0.20 m drip depth - 110% pre-irrigation, 3) every 1.02 m drip spacing – 0.30 m drip depth - 80% pre-irrigation, 4) every 1.02 m drip spacing – 0.30 m drip depth - 110% pre-irrigation, 5) every 2.03 m drip spacing – 0.20 m drip depth - 80% pre-irrigation, 6) Every 2.03 drip spacing – 0.20 m drip depth - 110% pre-irrigation, 7) Every 2.03 m drip spacing – 0.30 m drip depth - 80% pre-irrigation, and 8) Every 2.03 m drip spacing – 0.30 m drip depth - 110% pre-irrigation. The cotton variety Stoneville 1892 was planted on May 14th with a plant density of 133,465 plants per ha. A subsurface drip irrigation system was installed in Glasscock County. The drip system had emitters installed every 0.60 m and each emitter had a discharge of 0.91 L $h^{-1}$. The system could apply an irrigation depth of 1.5 mm $h^{-1}$. The relation between cotton and drip spacing treatments is presented in Fig. 1. The water characteristics are also shown in Table 1. Nitrogen fertilizer (N32) was applied in two applications: 49 kg/ha were applied on June 25$^{th}$, and 53.8 kg/ha on July 17$^{th}$. The soil was a clay loam soil with good drainage (29% sand, 42% silt, and 29% clay). Harvest data were gathered from within each plot mechanically by harvesting four rows. Seed cotton was weighed for each replication, and a portion (about 600 g) was ginned at the Texas A&M Agricultural Research and Extension Center in Lubbock, TX. Lint was analyzed for fiber quality at the International Textile Center of Lubbock. The lint yield, seed yield, loan value and total gross return data was analyzed with a general linear model (GLM) with mean separation by the least square difference (SAS Institute, 1991).

Table 1. Average field data, St. Lawrence, Glasscock County, TX. 2001.

| Operation | 2001 |
|---|---|
| Planting date | May 14 |
| First in-season irrigation | July 3 |
| First N-injection | June 25 |
| Second N-injection | July 17 |
| Last irrigation | September 7 |
| Harvest date | October 17 |
| EC of the water (micromhos/cm) | 4090 |
| SAR of the water | 14 |
| Rainfall for the calendar year (mm) | 368 |

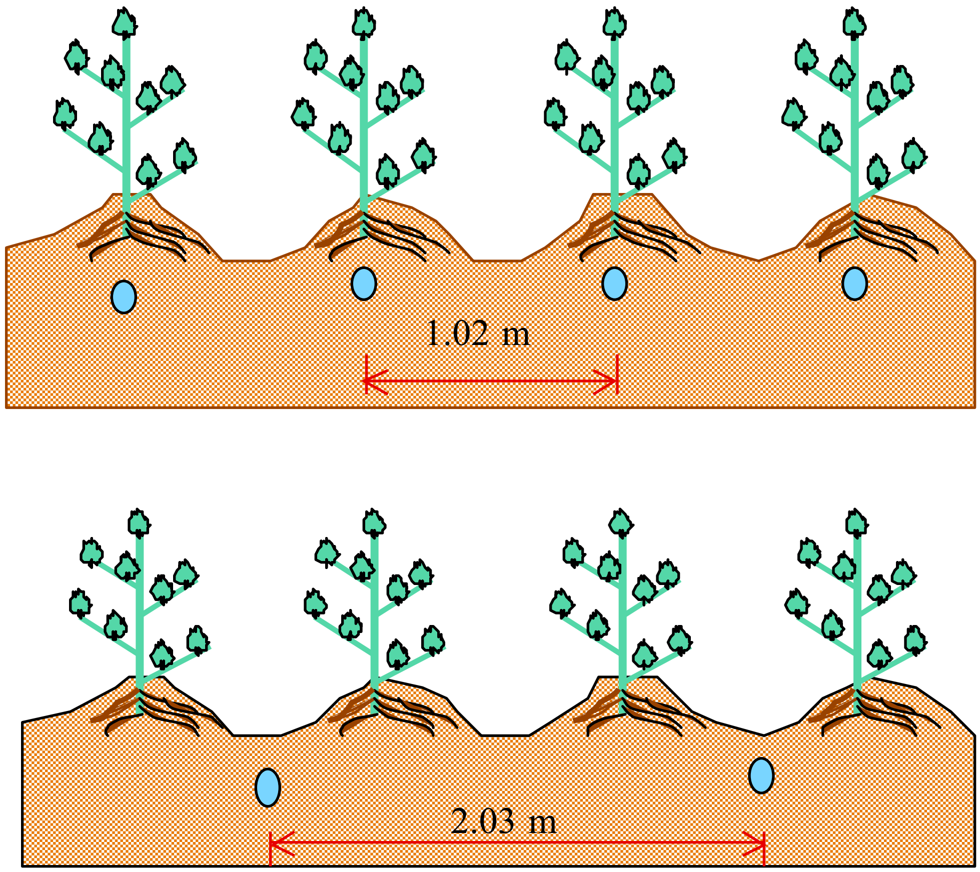


Fig. 1. Relation between drip spacing and cotton row spacing

**Results and Conclusions**

The pre-season and total irrigation depths are shown in Table 2. The low treatments received 130 mm during pre-season, and the high treatments received 180 mm. The highest water depth intended to have higher leaching from the soil profile before planting. After planting the low water treatments received more than the high treatments to end the season with the same total amount of water applied. The reason that some treatments received slightly more water than others is that there were slight fluctuations in the water pump from the wells. We controlled the irrigation times to apply the same amounts of water.

Table 2. Water use, cotton lint yield and water use efficiency for different drip spacing, depths and pre-irritations.

| Treatment | | Pre-water Depth (mm) | In-season Irrigation Depth (in) | Total Irrigation Depth (in) | Lint Yield (kg/ha) | Irrigation use efficiency (kg/m3) |
|---|---|---|---|---|---|---|
| Drip Spacing (m) | Drip Depth (m) | | | | | |
| 1.02 | 0.20 | 130 | 340 | 470 | 1187 | 0.252 |
| 1.02 | 0.20 | 180 | 282 | 462 | 1112 | 0.241 |
| 1.02 | 0.30 | 130 | 320 | 450 | 1245 | 0.276 |
| 1.02 | 0.30 | 180 | 272 | 452 | 1170 | 0.259 |
| 2.03 | 0.20 | 130 | 320 | 450 | 976 | 0.217 |
| 2.03 | 0.20 | 180 | 270 | 450 | 989 | 0.220 |
| 2.03 | 0.30 | 129 | 318 | 447 | 1068 | 0.239 |
| 2.03 | 0.30 | 180 | 267 | 447 | 1010 | 0.226 |

Soil salinity was measured at the beginning of the season. The soil salinity was 5 mmhos/cm and the SAR varied from 8 to 12. There were no differences on soil salinity and SAR between the 1.02 and 2.03 m drip spacing. An analysis of variance was done to study the effect of drip depth, spacing and water depth on lint yield, seed yield, loan value and total gross return. The loan value is an integrator of the cotton quality characteristics. There were no interactions between drip spacing, drip depth and total water depth when lint yield, seed yield, loan value and total gross return were analyzed. In Table 3, it can be observed that drip spacing had an effect on lint yield, seed yield, and total gross return, and did not have an effect on loan value. Lint yield, seed yield and total gross return resulted statistically higher for the 1.02-m than the 2.03-m drip spacing indicating higher yields for closer spacing. The spacing did not have an effect on cotton quality as it was indicated for the loan value. In Table 4, it can be observed that drip depth had an effect on lint yield, and total gross return, and did not have an effect on seed value and loan value. Lint yield and total gross return resulted statistically higher for the 0.3-m than the 0.2-m drip depth indicating higher yields for deeper drip depth, probably because of the higher soil evaporation of the shallower drip depth. The depth of the drip tape did not have an effect on cotton quality as it was indicated for the loan value. There was no effect of the different pre-water treatments on lint yield, seed yield, loan value, and total gross return.

Table 3. Effect of 1.0 and 2.0 drip spacing on lint yield, seed yield, loan value, and total gross return. Saint Lawrence, TX. 2001

| Drip spacing (m) | Lint yield (kg/ha) | Seed yield (kg/ha) | Loan value (¢/kg) | Total Gross return ($/ha) |
|---|---|---|---|---|
| 1.02 | 1178.4 a | 1015.7 | 24.72 | 1986.5 a |
| 2.03 | 1010.8 b | 825.4 | 24.54 | 1717.2 b |
| F | 0.0001 | 0.0288 | 0.4346 | 0.0001 |
| LSD | 51.64 | 168.6 | ----- | 95.61 |

Table 4. Effect of 0.20 and 0.3 m drip depth on lint yield, seed yield, loan value, and total gross return. Saint Lawrence, TX. 2001

| Drip depth (m) | Lint yield (kg/ha) | Seed yield (kg/ha) | Loan value (¢/kg) | Total Gross return ($/ha) |
|---|---|---|---|---|
| 0.30 | 1123.3 a | 912.4 | 24.49 | 1890.7 |
| 0.20 | 1065.9 b | 928.8 | 24.78 | 1813.0 |
| F | 0.0309 | 0.8419 | 0.2010 | 0.1058 |
| LSD | 51.64 | ---- | ----- | ----- |

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