Knifing versus Injecting Phosphorus with SDI Systems in Cotton

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Abstract

Presently, one of the problems farmers are facing in West Texas after continuously raising cotton for 10 years on previously installed SDI systems is the depletion of nutrients. Since SDI systems wet a portion of the soil forming a wetting bulb, most of the nutrients are absorbed from this portion where the water infiltrates. This process has depleted nutrients that otherwise would have been plentiful for uptake given that the soils are rich on them, mainly nutrients such as phosphorus (P) and potassium (K). In comparison, furrow systems wet a larger volume, which presumably would encourage roots to spread, providing a larger access to nutrients. Some SDI farmers have observed large increases on cotton lint yields just by the addition of small amounts of phosphorus. Several questions arise regarding these applications, such as what are the most appropriate rates or whether to split the rates between the phenological stages. Furthermore, there is uncertainty concerning the most efficient method to apply phosphorus and potassium. These nutrients can be either knifed into the soil, or injected through the irrigation system. SDI systems allow splitting injections during the growing season at a low cost. The effect of knifing versus injecting the phosphorus into the irrigation system in two applications was evaluated. The experiment was completely randomized with four treatments and four replications. The treatments were: 1) No phosphorus applications; 2) Knifing the phosphorus into the soil, 3) applying 15.1 L (4 gallons) of phosphoric acid in one application, 4) applying 15.1 L (4 gallons) of phosphoric acid in two applications. The phosphorus rates applied in both the knifing and injection applications were similar. Although not statistically different, the knifed phosphorus resulted in numerically higher seed cotton weights than the yield obtained with the injection of phosphorus through the subsurface drip irrigation system in 2004. Statistically, there was no difference between knifing or injecting the phosphorus during the first year of the experiment. The experiment got hailed out in 2005.

Introduction

The adoption of subsurface drip irrigation (SDI) for cotton production in Texas has increased dramatically in the last 10 years. In 1994, Henggeler listed the SDI cotton acreage to be about 3300 acres (10% of the irrigated acreage of St. Lawrence area). This year according to Bryan Frerich there are about 220,000 cotton acres with SDI in the state of Texas (Frerich, 2004). The most intensive area with cotton using SDI remains in the St. Lawrence area of Texas (Upton, Reagan and Glasscock Counties), and the Lubbock area. Declining water resources and small irrigation system capacities have pushed this trend up, and also perhaps the fact that irrigation efficiencies (defined as lint yield divided by gross irrigation applied) above 24 kg/ha-cm (55 lbs/ac-in) can be obtained with SDI systems (Enciso et al., 2002; 2003). In comparison, irrigation efficiencies of 15 kg/ha-cm (35 lbs/ac-in) are generally obtained with furrow systems.

One of the problems farmers are facing after continuous cotton production with SDI for 10 years is the depletion of nutrients. Since SDI systems wet a smaller volume of the soil, a smaller root zone would presumably result, and nutrients such as phosphorus (P) and potassium (K) are absorbed from a much smaller volume. With furrow systems, a larger volume is wetted, presumably resulting in a larger root volume and hence a greater access to soil nutrients. Some SDI farmers have observed large increases on cotton lint yields just by the addition of small amounts of phosphorus. Several questions arise regarding these applications, such as what are the most appropriate rates, or whether to split the rates between the phenological stages. Another question is what is the most efficient method to apply phosphorus and potassium. These nutrients can be applied on the surface and knifed into the soil to depths of approximately 10 cm, or injected through the irrigation system (fertigation). Considering that P is relatively immobile in the soil, injecting P into the soil through SDI may increase its distribution through mass flow of water and saturation of cation exchange points compared with knifing (Bar-Yosef, 1999; Lamm et al., 2006). The injection of P and K with SDI irrigation systems under high frequency has increased tomatoes yields considerably without increasing water use, resulting in higher water use efficiency (Phene et al., 1990). However, one of the challenges of phosphoric acid injection into the irrigation system in desert environments is that water generally is hard (high in calcium and magnesium), which can result in precipitation of phosphates and clog drip emitters if the irrigation water is not acidified (Burt et al., 1998). Alternatively, phosphoric acid could be injected at a sufficiently high rate so as to maintain irrigation water pH at approximately 4.0 or less.

We hypothesize that, despite some risks with emitter clogging by injecting phosphoric acid, cotton lint yields might be increased by fertigation relative to knifing. The objectives of this study were to evaluate the cotton yield response of phosphorus application through 1) knifing; 2) single large application of fertigation; and 3) two smaller applications of fertigation.

Material and Methods

The experiment was conducted on a farm owned by a cooperating cotton producer in St. Lawrence, TX during the 2004 and 2005 seasons. The cotton variety Deltapine[1] 488 BR was planted on 24 May, 2004 on raised beds with 1.02 m spacing. The soil was a clay loam soil with good drainage (29% sand, 42% silt, and 29% clay). Irrigation was applied using subsurface drip irrigation (SDI). The SDI system had emitters installed every 60 cm and each emitter had a discharge of 0.91 L/h. The drip-line was spaced every 1.02 m (beneath each planted bed) at a 30-cm depth. This resulted in an application rate of 0.15-cm h^{-1}. Tillage practices consisted of stalk chop and list, plant, and two applications of round up Ultra Max®.

The experiment was completely randomized with four treatments and four replications, with a total of 16 plots. Each plot consisted of four 290-m long cotton rows. The treatments were: 1) No phosphorus applications; 2) Knifing 33.6 kg ha^{-1} of P_2O_5 into the soil using ammonium polyphosphate (10-34-0); 3) Injection of 33.6 kg ha^{-1} of P_2O_5 in one application using phosphoric acid; 4) Injection of 33.6 kg ha^{-1} of P_2O_5 in two applications (16.8 kg ha^{-1} each) using phosphoric acid. Liquid nitrogen (UAN32) was injected through the irrigation system on 25 July 2004 at 127 kg ha^{-1}. (this was reduced to 117 kg ha^{-1} for the knifing treatment to account for the N present in the 10-34-0). The fertilizer 10-34-0 was knifed on 30 June 2004; the phosphoric acid was applied on 15 July 2004 in a single 15.1 L application, and on 15 July and 1 August 2004 for two 7.6 L applications. Watermark blocks were installed to qualitatively assess soil wetness by estimating soil matric potential. Rainfall and weather data were recorded daily.

Harvest data were gathered from within each plot mechanically by harvesting four rows. Seed cotton was weighed for each replication, and a portion (about 0.60 kg) was ginned at the Texas A&M Agricultural Research and Extension Center in Lubbock, TX. The seed cotton weight was analyzed with a general linear model (GLM) with mean separation by the least square difference (SAS Institute, 1991).

Results

During the 2004 season, 21.3 cm of rainfall received (Table 2). Preplant irrigation (15.3 cm) was applied depth from March 23 to May 6, and an in-season irrigation depth (26.4 cm) from May 21 to August 21. In 2005, preplant irrigation (9.9 cm) was applied from April 15 to May 24, and an in-season irrigation (26.4 cm) was applied from June 25 to August 15. A hail storm occurred on July 17 that severely damaged the plots and low cotton yields were obtained, therefore the results of 2005 are not reported.

[1] The mention of trade or manufacturer names is made for information only and does not imply an endorsement, recommendation, or exclusion by Texas A&M University or the USDA-Agricultural Research Service.

Table 2. Rainfall (cm) received during 2004 and 2005.

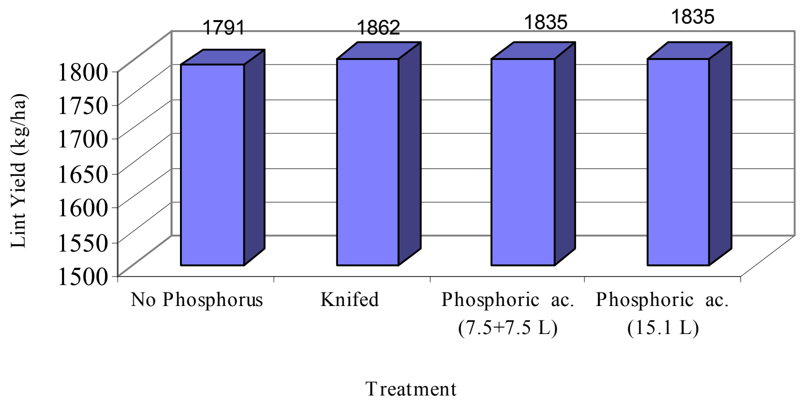
Month	2004	2005
Jan	2.1	0.7
Feb	1.9	6.9
Mar	5.9	6.6
April	8.5	0.2
May	0.2	11.1
June	18.4	6.8
July	5.4	9.5
Aug	12.0	46.6
Sep	12.2	0
Oct	0.3	17.8
Nov	0	0
Dec	0	0.04
Annual total	66.9	106.2
Preplant rainfall	10.9	7.0
In-season rainfall	35.8	65.5

There was not any statistical difference on lint cotton yield between the treatments of the experiment (Fig. 1). Although not statistically different, the knifed phosphorus resulted in numerically higher seed cotton weights than the yield obtained with the injection of phosphorus through the subsurface drip irrigation system. The average yield for the knifed phosphorus was 26.9 kg ha^{-1} (24 lbs ac^{-1}) higher than the injected phosphorus through the drip system and 70.6 kg ha^{-1} (63 lbs ac^{-1}) higher than the no phosphorus application treatment. These results do not support the hypothesis where the deeper placement of phosphorus through fertigation (approximately 30 cm) would improve cotton yields relative to the shallower placement of nutrients by knifing (approximately 10 cm). There was no difference between splitting the phosphorus in two applications or in applying it in only one application; the yields were similar for these treatments. It is important to obtain data for more years to draw any valid conclusions.

Conclusion

Statistically, there was no difference between knifing or injecting the phosphorus during 2004. In 2005, the experiment got hailed out. Another year is necessary to make conclusions.

Fig. 1. Cotton lint yield (kg/ha) response to different phosphorus applications in 2004.



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