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# ADVANCES IN SDI FERTIGATION FOR CORN

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## *QUICK FACTS*

- *Combining SDI and fertigation can improve spatial and temporal nutrient management.*
- *Fertigation, as well as any chemigation activity, needs to be carefully managed in accordance with state and federal laws.*
- *Many benefits with SDI fertigation are potentially available, but can equally become challenges if managed insufficiently.*
- *SDI can better manage both nitrogen and phosphorus applications through inseason fertigation, resulting in better crop yields and increased nutrient efficacy.*
- *SDI fertigation is a good tool to incorporate with intensive management of other inputs, and the potential exists to further improve corn yields while maintaining high water productivity (crop per drop).*

## INTRODUCTION

The process where nutrient application or fertilization is accommodated by joint application of water and nutrients through the system is called fertigation. Fertigation is the term used specifically for nutrient application through the irrigation system, whereas chemigation is the broader term used to describe application of any chemical solution through the irrigation system.

Field corn (maize) uses considerable quantities of nutrients, and their effectiveness can be affected by timing of application and their retention or positioning within the crop root zone. Some of these nutrients are mobile, subject to leaching (e.g., nitrogen), while others are rather immobile, and this may limit their root uptake (e.g., phosphorus). Subsurface drip irrigation can spoon-feed both water and nutrients to the root zone and as a result can better manage the two. This can limit the amount of nonbeneficial water losses and apply nutrients just-in-time as needed.

Numerous studies have been conducted around the world with SDI fertigation for a multitude of crops and a full discussion of the results lies beyond the scope of this paper. The scope of this paper will be limited to a brief discussion of

- Mechanics of SDI fertigation,
- Benefits and challenges of SDI fertigation,
- A few examples of benefits from our studies at K-State Research and Extension.

The goal of this paper is not to answer all of your potential questions about SDI fertigation for corn. Rather, the goal is to help inform you of important aspects you should consider about SDI fertigation and to help you consider its potential utilization in your operation.

# MECHANICS OF SDI FERTIGATION

Subsurface drip irrigation (SDI) applies water below the soil surface to the crop root zone through small emission points (emitters) that are in a series of plastic lines typically spaced between alternate pairs of crop rows (Figure 1). When considering developing an SDI system for use on their farm, irrigators should make sure the design uniformity will be sufficient for fertigation [i.e., emission uniformity should be 95% or higher (Smajstrla et al., 1990)].

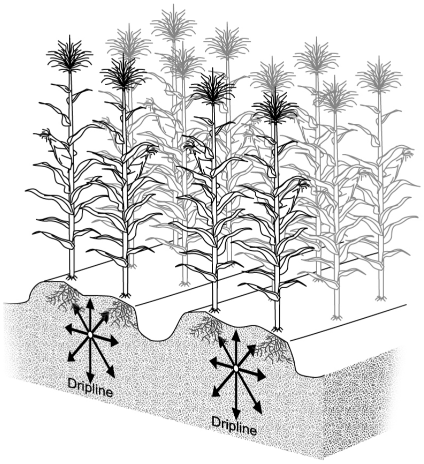


Figure 1. Alternate row/bed 5 ft SDI dripline spacing for corn rows spaced at 2.5 ft. Each plant row is approximately 1.25 ft from the nearest dripline and has equal opportunity to the applied water and with fertigation also to nutrients.

## Legal Requirements of SDI Fertigation

Since fertigation involves a physical mixing of agrochemicals with the irrigation water, state or federal laws may dictate its practice and also the equipment requirements to help prevent contamination of the water supply. Irrigators must check into and follow the requirements that are set forth in state or federal laws and should note that state laws often vary in the Central Plains region. An easy starter on determining your own state's laws is to Google your state's name and the words chemigation requirement.

## Chemigation Equipment

Certain basic features should be universal throughout all SDI systems (Figure 2). The long-term efficient operation and maintenance of the system is seriously undermined if any of these minimum components are omitted during the design process. A more detailed discussion of these components is provided by Lamm et al. (2018). It should be noted that the location of the chemical injection system can be different, depending upon the chemicals being injected. In cases where there can be varying qualities of the fertilizer source solution in terms of contaminants, it is useful to inject before the filtration system. However, when corrosive materials are injected into the SDI system, the chemical injection system may be downstream of the filtration system. In addition to SDI system protection, the chemical injection system may also be used to inject nutrients or chemicals into the water to enhance plant growth or yield. A variety of injectors can be used, but the choice of unit depends on the desired injection accuracy for the chemical, the rate of injection, the chemical being injected, and applicable state or federal laws.

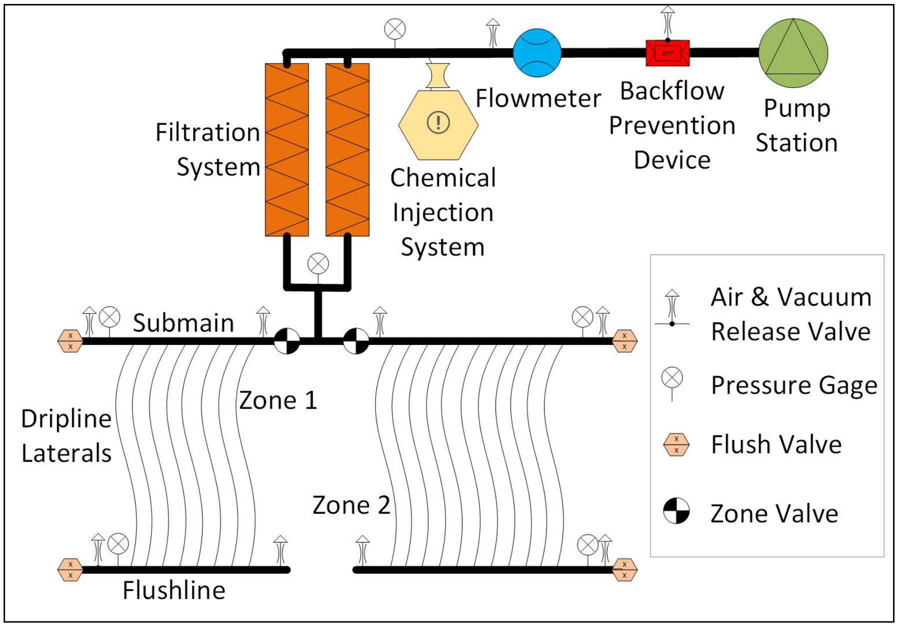


Figure 2. Minimum required components of an SDI system. Components are not to scale. After Lamm et al., 2018.

Positive displacement pump injectors are commonly used in agricultural settings (Figure 3), but there are other types that may be appropriate in some settings. When a wide variety of chemicals are likely to be injected, then more than one type of injection system may be required. For example, chlorine and acid should be injected separately and separated by a distance of 6 to 10 feet.

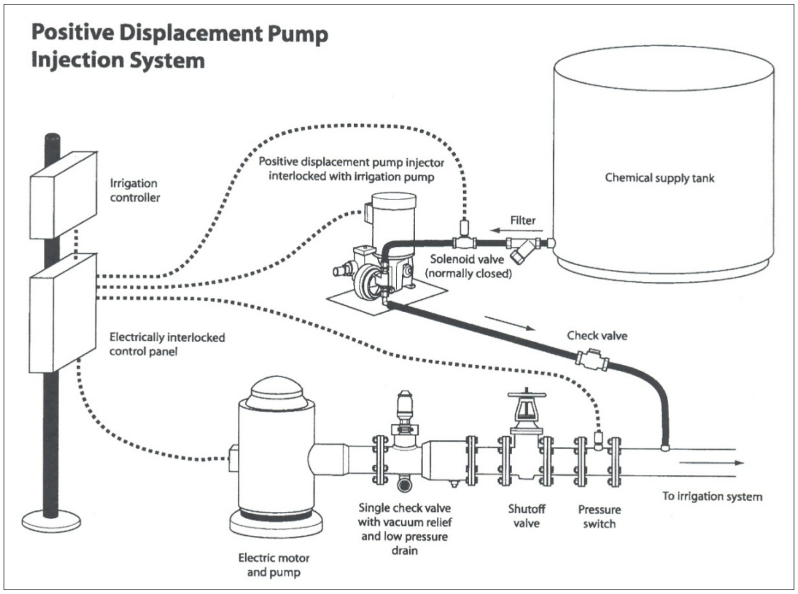


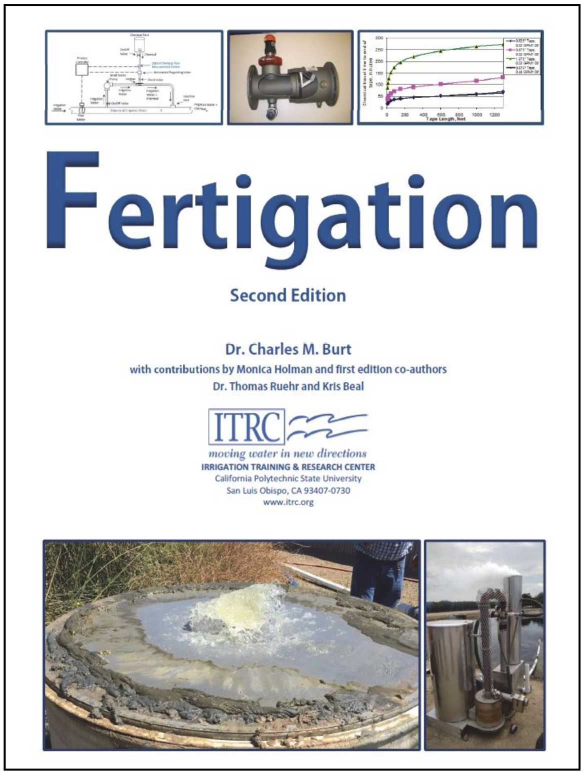
Figure 3. Positive displacement pump injection system with associated safety components to help prevent contamination events. Drawing courtesy of L. Schwankl, Univ. of California-Davis.

## Chemical Compatibility

Figure 4. Chemical precipitation in an SDI dripline.

Producers should avoid injecting any chemical into their SDI system without knowledge of the chemical compatibility with irrigation water. Water chemistry can be affected by pressure, temperature, pH, natural occurring constituents in the water and their concentration, and the interactions and concentrations of the intended agrochemical for injection. Under some unfortunate circumstances, these factors can combine and cause chemical precipitation which may clog the dripline and emitters. One easy method to test your water source and the chemical compatibility is to use a jar test where the chemical at an appropriate concentration is added to a known quantity of water in a jar and allowed to rest overnight to see if chemical precipitation occurs. Methods to perform a jar test are available from many sources, so you can just Google *chemical compatibility jar test.* Phosphorous fertilizers are particularly tricky and can combine with constituents in the water to cause insoluble precipitates that can clog the emitters. It is suggested that irrigators gain some experience before tackling phosphorous fertigation.

Over time you may want to use your fertigation capabilities with numerous products, so you should strongly consider getting some good resources to help guide you in the process. One good resource is the book ***Fertigation*** which can be obtained from the Irrigation Training & Research Center (ITRC) California Polytechnic State University, San Luis Obispo, California. You can easily find ordering information for this book with Google *ITRC Publications for Sale.*



Fertigation

Second Edition

Dr. Charles M. Burt
with contributions by Monica Holman and first edition co-authors
Dr. Thomas Ruehr and Kris Beal

ITRC
moving water in new directions
IRRIGATION TRAINING & RESEARCH CENTER
California Polytechnic State University
San Luis Obispo, CA 93407-0730
www.itrc.org

Figure 5. Fertigation handbook available from Irrigation Training & Research Center.

# BENEFITS AND CHALLENGES OF SDI FERTIGATION

There are many potential benefits and challenges to SDI fertigation. It should also be noted some benefits that occur when managed correctly can become difficult challenges when management is insufficient. Some of these benefits and challenges are also discussed in Bar Yosef (1999) and USDA-NRCS (2013).

## Labor and System Management Benefits for SDI Fertigation

- System costs can be spread across both irrigation and nutrient applications.
- Less heavy tractor usage in field, less compaction.
- Unaffected by wind and precipitation that might cause off-site movement.
- Leaching of nutrients can be better managed both spatially and temporally.
- Potentially less labor and energy costs.
- Precise and timelier applications can increase chemical efficacy and efficiency.

## Labor and System Management Challenges for SDI Fertigation

- Some limitations on nutrients that can be applied, and some chemical compatibility issues can be daunting to irrigators.
- Nutrient application uniformity can be affected by SDI design characteristics that have less effect on irrigation, such as purging the system of fertilizers while keeping application in root zone for some crops.
- Smaller root zones can make irrigation and fertilization critical issues from both timing and quantity perspectives.
- Higher skill and experience may be required for labor.
- When water and nutrients are highly managed for greatest effectiveness, there can be less margin of error.
- Safety and environmental concerns when field inventories of nutrients are commonplace for longer periods during the season.
- Potential for contamination of water sources through unintended backflow.

## Crop and Soil Benefits for SDI Fertigation

- Reduced temporal fluctuation in nutrient concentrations in soil, and concentrations can be manipulated throughout the cropping season. There are some theoretical reasons this can be important in optimizing crop yield (Bar-Yosef, 1999).
- Crop foliage remains dry, reducing development of pathogens, and avoiding leaf burn.
- Better control of nutrient redistribution in soil.
- Concentration of nutrients in active root zone.
- Allows easy application of micronutrients.
- Can be helpful in moving less mobile nutrients to root tips through mass flow.
- Crop yield can be increased without increase in transpiration, thus increasing crop water productivity.
- Opportunities for intensification of crop production when combined with other optimization practices.

### Crop and Soil Challenges for SDI Fertigation

- Nutrient redistribution may be too small on coarse-textured soils, resulting in a limited nutrient availability.
- Some nutrients not suitable for distribution through SDI system.
- Restricted plant root development may lead to increased management requirements.

As noted earlier, some benefits also were listed as challenges. This strongly emphasizes that careful management is required to obtain the benefits.

## A FEW BENEFITS FROM OUR FERTIGATION STUDIES AT K-STATE

A number of SDI fertigation studies have been conducted at the KSU Northwest Research-Extension Center at Colby, Kansas, beginning in 1990. This brief summary will focus on key field research results to illustrate some of the benefits obtained in our studies:

- Nitrogen levels can be decreased with SDI fertigation.
- Inseason fertigation may be beneficial when irrigation is deficit.
- Inseason phosphorous fertigation increases corn yield and water productivity.
- Fertigation is a useful addition to intensification of crop production with SDI.

### Nitrogen Levels can be decreased with SDI

In an early study at Colby, 1990-1991, results indicated that nitrogen applied with SDI redistributed differently in the soil profile than surface-applied preplant N (Lamm et al., 2001). Although corn yields were similar between the two fertilization methods, there was greater residual soil-N for the SDI fertigation (Figure 10).

The additional inseason fertigation allowed for healthier and more vigorous plants that were better able to utilize soil water. The results suggest that a large portion of the applied N could be delayed until weekly injections begin with the first irrigation, provided there is sufficient residual soil N available for early growth. In both years, nearly all of the residual nitrate nitrogen measured after corn harvest was located in the upper 12 inches of the soil profile for the preplant surface-applied nitrogen treatments, regardless of irrigation level. In contrast, nitrate concentrations increased with increasing levels of nitrogen injected with SDI and migrated deeper in the soil profile with increased irrigation (Figure 6). This led to a study to determine if SDI fertigation N needs could be lowered and still retain excellent yields.

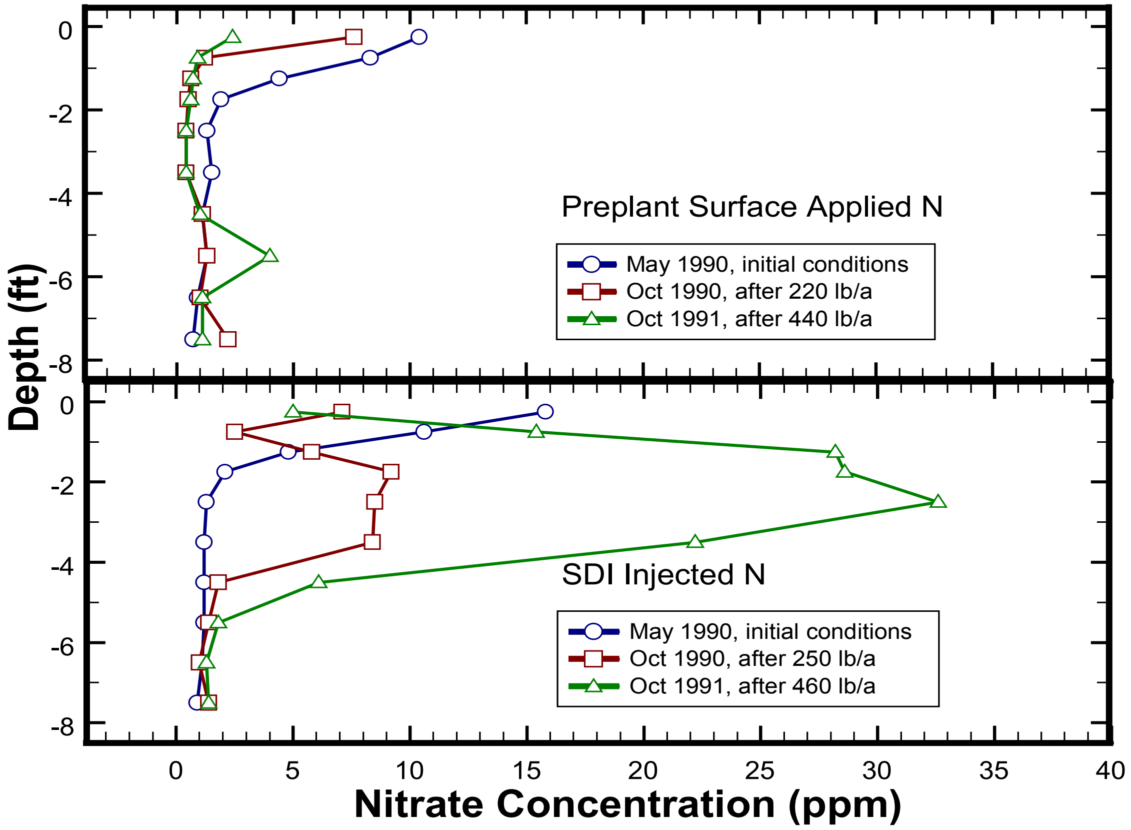


Figure 6. Nitrate concentrations in the soil profile for preplant surface-applied and SDI injected nitrogen treatments, KSU Northwest Research-Extension Center, Colby, Kansas, 1990-91. Data is for selected nitrogen fertilizer rate treatments with full irrigation (100% of ETc-Rain).

This follow-up four year study was conducted at the KSU Northwest Research-Extension Center at Colby, Kansas on a deep Keith silt loam soil to develop a Best Management Practice (BMP) for nitrogen fertigation for corn using SDI (Lamm et al., 2004). Residual ammonium- and nitrate-nitrogen levels in the soil profile, corn yields, apparent nitrogen uptake (ANU) and water productivity (WP) were utilized as criteria for evaluating six different nitrogen fertigation rates, 0, 80, 120, 160, 200, and 240 lbs N/a. The final BMP was a nitrogen fertigation level of 160 lbs N/a with other nonfertigation applications bringing the total applied nitrogen to approximately 190 lbs N/a (Lamm et. al., 2004). The BMP also states that irrigation is to be scheduled and limited to replace approximately 75% of ET. Corn yield, ANU, and WP all plateaued at the same level of total applied nitrogen, which corresponded to the 160 lbs N/a nitrogen fertigation rate (Figure 7). Average yields for the 160 lbs N/a nitrogen fertigation rate was 213 bu/a. Corn yield to ANU ratio for the 160 lbs N/a nitrogen fertigation rate was high at 53:1 (lbs corn grain/lbs N whole-plant uptake). The results emphasize that high-yielding corn production also can be environmentally sound and efficient in nutrient and water use.

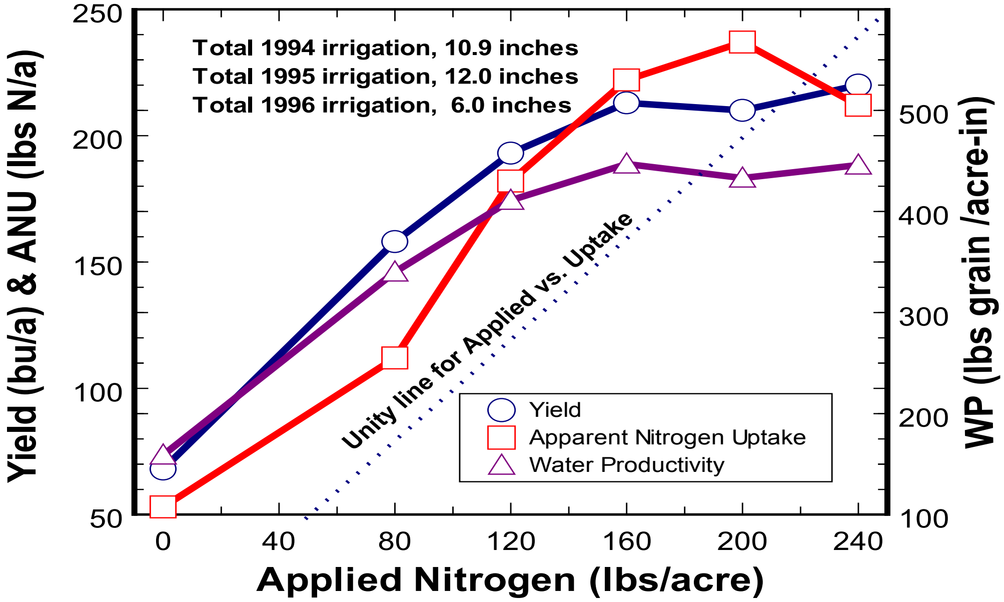


Figure 7. Average (1994-96) corn yield, apparent nitrogen uptake in the above-ground biomass, and water productivity as related to the total applied nitrogen (preseason amount, starter fertilizer, fertigation, and the naturally occurring N in the irrigation water). Total applied nitrogen exceeded fertigation applied nitrogen by 30 lb/acre.

After 4 years of continuous application of the fertigation treatments (Figure 8), nitrate-N levels in the soil were increasing and moving downward when the fertigation rate exceeded 160 lb N/a (i.e., equivalent to 190 lbs N/a total applications from all sources).

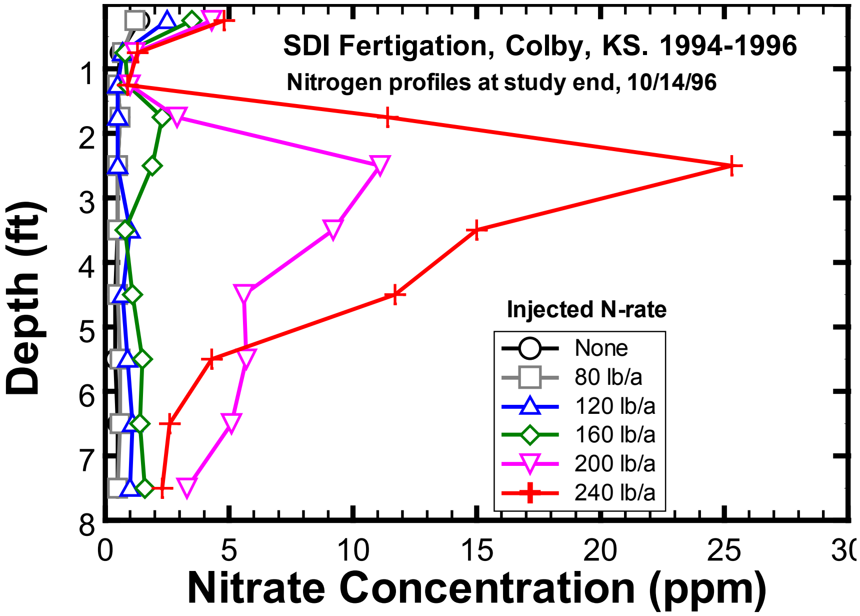


Figure 8. Nitrate concentrations within the 8-ft soil profile as affected by SDI fertigation N rate after four years of continuous application, KSU Northwest Research-Extension Center, Colby Kansas.

## Inseason Fertigation may be beneficial when Irrigation is Deficit.

A study was conducted at the KSU Northwest Research-Extension Center at Colby, Kansas in 2010 and 2012 to examine subsurface drip irrigation (SDI) capacity and nitrogen fertigation timing on corn production (Lamm and Schlegel, 2013). All treatments received a pre-plant broadcast surface application of 125 lbs N/acre in the form of UAN 32-0-0. Additional targeted SDI N fertigation events of 70 lbs N/acre (UAN 32-0-0) at 3 specific early season growth stages (V5, V9, or VT) were compared under 2 levels of irrigation (0.25 inches/day or 0.25 inches/2 days). Treatment effects were evaluated in terms of corn yield components, crop water use, and crop water productivity. Overall, corn grain yields, kernels/area, kernel mass, and water productivity generally were numerically greater when nitrogen fertigation timing was earlier in the crop growth and development (Table 1).

**Table 1. Corn yield component, biomass, and water use results from a subsurface drip irrigated corn study as affected by irrigation capacity and nitrogen fertigation timing, KSU Northwest Research-Extension Center, Colby Kansas, 2010 and 2012.**

| Irrigation capacity | N-Fertigation timing | Yield, bu/a | Kernels/area, Million Kernels/acre | Kernel mass, mg | Biomass, lb/a | Water use, in | WP, lb/a-in |
|---|---|---|---|---|---|---|---|
| ***Crop year, 2010*** | | | | | | | |
| 0.25 in/d | None | 155.0 | 14.11 | 279 | 14219 | 23.08 | 376 |
| | V6 | 277.0 | 18.71 | 376 | 22003 | 23.62 | 657 |
| | V9 | 237.0 | 17.82 | 336 | 19143 | 23.33 | 569 |
| | VT | 239.2 | 17.60 | 345 | 19365 | 23.66 | 566 |
| Mean 0.25 in/d | V6 thru V9 | 251.1 | 18.04 | 353 | 20170 | 23.54 | 597 |
| | | | | | | | |
| 0.25 in/2 d | V6 | 241.4 | 19.00 | 323 | 16493 | 21.97 | 615 |
| | V9 | 238.2 | 18.68 | 324 | 18869 | 21.72 | 614 |
| | VT | 239.5 | 17.55 | 347 | 17070 | 21.52 | 624 |
| Mean 0.25 in/2 d | V6 thru V9 | 239.7 | 18.41 | 331 | 17477 | 21.73 | 617 |
| ***Crop year, 2012*** | | | | | | | |
| 0.25 in/d | None | 185.0 | 14.78 | 318 | 12150 | 29.13 | 358 |
| | V6 | 246.5 | 17.69 | 354 | 20152 | 28.33 | 499 |
| | V9 | 235.6 | 17.14 | 349 | 17826 | 27.86 | 477 |
| | VT | 248.1 | 17.92 | 352 | 20551 | 26.09 | 536 |
| Mean 0.25 in/d | V6 thru V9 | 243.4 | 17.58 | 351 | 19510 | 27.43 | 504 |
| | | | | | | | |
| 0.25 in/2 d | V6 | 218.8 | 15.74 | 353 | 18431 | 19.29 | 644 |
| | V9 | 220.9 | 16.05 | 349 | 17635 | 22.27 | 554 |
| | VT | 224.2 | 16.08 | 354 | 15058 | 20.99 | 609 |
| Mean 0.25 in/2 d | V6 thru V9 | 221.3 | 15.96 | 352 | 17041 | 20.85 | 602 |
| ***Mean, both years*** | | | | | | | |
| 0.25 in/d | None | 170.0 | 14.44 | 299 | 13184 | 26.11 | 367 |
| | V6 | 261.7 | 18.20 | 365 | 21077 | 25.98 | 578 |
| | V9 | 236.3 | 17.48 | 343 | 18485 | 25.59 | 523 |
| | VT | 243.7 | 17.76 | 348 | 19958 | 24.87 | 551 |
| Mean 0.25 in/d | V6 thru V9 | 247.2 | 17.81 | 352 | 19840 | 25.48 | 551 |
| | | | | | | | |
| 0.25 in/2 d | V6 | 230.1 | 17.37 | 338 | 17462 | 20.63 | 629 |
| | V9 | 229.5 | 17.37 | 337 | 18252 | 22.00 | 584 |
| | VT | 231.8 | 16.81 | 351 | 16064 | 21.25 | 616 |
| Mean 0.25 in/2 d | V6 thru V9 | 230.5 | 17.18 | 342 | 17259 | 21.29 | 610 |

The greatest corn grain yield and greatest water productivity was obtained in 2010 by the fully irrigated treatment receiving supplemental nitrogen fertigation at the V6 growth stage. Averaged over the two years, supplemental nitrogen fertigation at the V6 stage was most beneficial to grain yield response when the crop was fully irrigated, particularly in 2010. In contrast, timing of the nitrogen fertigation had little effect on the deficit-irrigated treatments. When supplemental nitrogen fertigation was not added to the base 125 lbs/acre preplant-applied nitrogen, corn grain yields were greatly reduced with a 44% reduction in the more normal year, 2010, and a 25% reduction in the drought year, 2012. The lack of supplemental nitrogen fertigation greatly reduced grain yields and water productivity in both years.

Differences in the intermediate yield component, kernels/area (i.e., plants/area x ears/plant x kernels/ear) could explain the corn grain yield differences for the fully irrigated V6 treatment in 2010 and for the nonfertigated treatment in both years (Table 1 and Figure 9). Generally, the potential kernel number is set between V6 and V9, while the actual kernel number is finalized by about 2 weeks after pollination (R1 growth stage). The lack of the supplemental nitrogen fertigation had the greatest effect on the kernels/area value in the more normal year 2010.

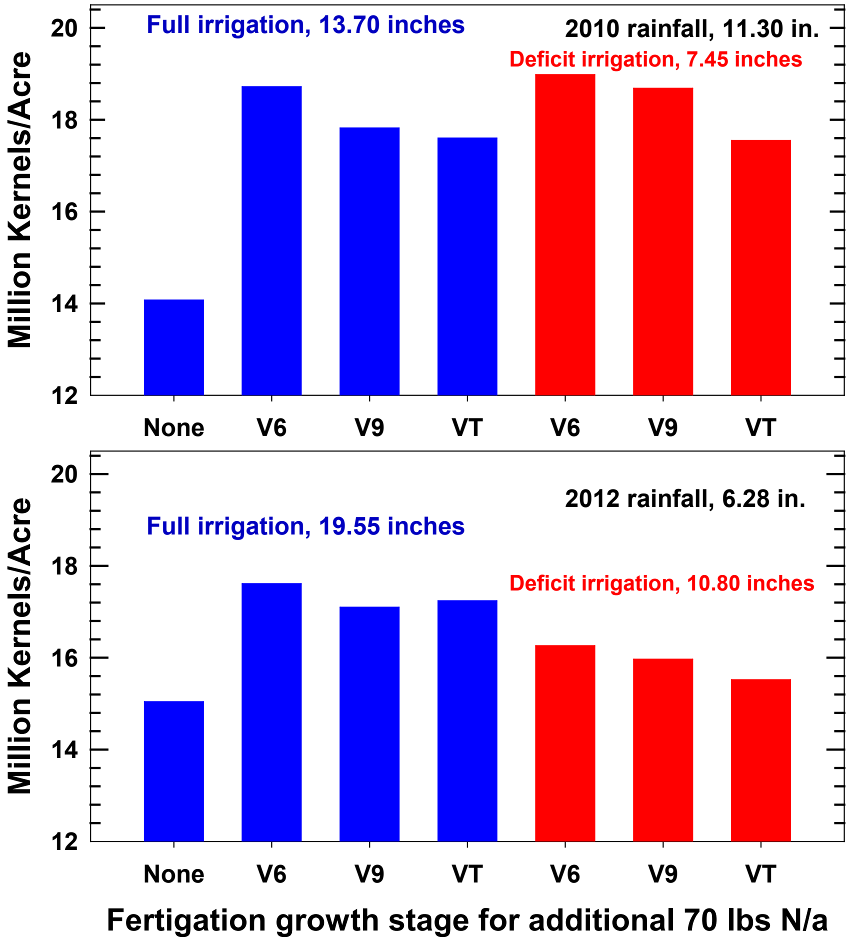


Figure 9. Kernels per unit land area as affected by irrigation regime and supplemental nitrogen fertigation timing for a subsurface drip irrigated corn study at the KSU Northwest Research-Extension Center, Colby, Kansas, 2010 and 2012.

Kernel mass was greatest for the fully irrigated V6 fertigation treatment in 2010 and was much lower when there was no supplemental fertigation in both years (Table 1 and Figure 10). Timing of fertigation had little or no effect on kernel mass in the drought year 2012. The lack of the supplemental fertigation had the greatest effect on kernel mass in the more normal year 2010.

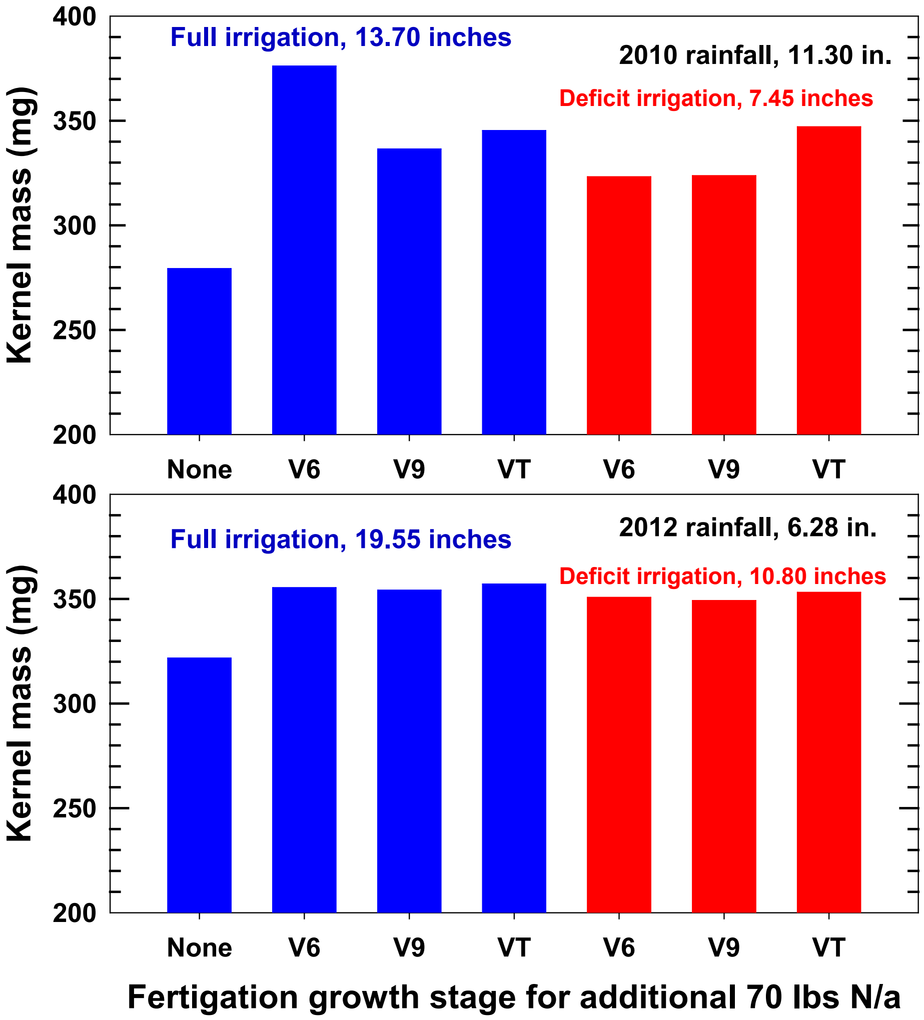


Figure 10. Kernel mass as affected by irrigation regime and supplemental nitrogen fertigation timing for a subsurface drip irrigated corn study at the KSU Northwest Research-Extension Center, Colby, Kansas, 2010 and 2012.

Appropriate timing of N fertigation had the greatest positive effect under full irrigation in the more normal year 2010, because of both greater kernels/area and much greater kernel mass. Conjunctive management of both irrigation and inseason N fertigation are important for corn production with SDI.

### Inseason Phosphorous Fertigation Increases Corn Yield and Water Productivity

A study was conducted at the KSU Northwest Research-Extension Center at Colby, Kansas from 2015 to 2017 to examine timing of inseason phosphorus fertigation for corn production using SDI. The fertilizer treatments, yield, and water use results are shown in Table 2.

**Table 2. Fertilizer treatments, corn yield, and water use parameters in a phosphorus fertigation study using SDI at KSU-NWREC, Colby, Kansas from 2015 to 2017. Note: All treatments received a total of 220 lbs N/acre and 40 lbs P/acre in each year.**

| Fertilizer Treatment | Applied at Planting | Inseason Fertigation | | |
|---|---|---|---|---|
| | | 5 to 10 Leaves | 11 Leaves to Tasseling | Tasseling to Blister Kernel |
| 1<br>No P fertigation | 44 lbs N/a, 40 lbs P/a + banded Zinc | 66 lbs N/a | 66 lbs N/a | 44 lbs N/a |
| 2<br>P Fertigation Trt 1 | 44 lbs N/a, 24 lbs P/a + banded Zinc | 66 lbs N/a, 4 lbs P/a | 66 lbs N/a, 8 lbs P/a | 44 lbs N/a, 4 lbs P/a |
| 3<br>P Fertigation Trt 2 | 44 lbs N/a, 16 lbs P/a + banded Zinc | 66 lbs N/a, 8 lbs P/a | 66 lbs N/a, 12 lbs P/a | 44 lbs N/a, 4 lbs P/a |
| 4<br>P Fertigation Trt 1 | 44 lbs N/a, 24 lbs P/a + 50% banded Zinc | 66 lbs N/a, 4 lbs P/a + 25% foliar Zinc | 66 lbs N/a, 8 lbs P/a | 44 lbs N/a, 4 lbs P/a |
| 5<br>P Fertigation Trt 2 | 44 lbs N/a, 16 lbs P/a + 50% banded Zinc | 66 lbs N/a, 8 lbs P/a + 25% foliar Zinc | 66 lbs N/a, 12 lbs P/a | 44 lbs N/a, 4 lbs P/a |

| Fertilizer Treatment No. | Yield (bu/a) | Plant Density (plants/a) | Ears /Plant | Kernels /Ear | Kernel Mass (mg) | Crop Water Use (in) | Water Productivity (lb/acre-in) |
|---|---|---|---|---|---|---|---|
| ***Crop Year, 2015*** | | | | | | | |
| 1 | 246 | 34412 | 0.97 | 562 | 332 | 28.97 | 476 |
| 2 | 278 | 33541 | 1.00 | 609 | 346 | 28.68 | 544 |
| 3 | 260 | 33323 | 0.99 | 595 | 336 | 29.13 | 501 |
| 4 | 273 | 33977 | 0.99 | 623 | 332 | 27.53 | 555 |
| 5 | 266 | 33541 | 0.99 | 607 | 337 | 27.69 | 539 |
| ***Crop Year, 2016*** | | | | | | | |
| 1 | 258 | 33323 | 1.00 | 536 | 368 | 25.16 | 575 |
| 2 | 276 | 33323 | 0.99 | 591 | 361 | 25.26 | 612 |
| 3 | 284 | 33106 | 1.00 | 600 | 362 | 25.44 | 624 |
| 4 | 274 | 33759 | 0.99 | 590 | 354 | 25.52 | 602 |
| 5 | 272 | 33541 | 0.98 | 568 | 370 | 25.60 | 595 |
| ***Crop Year, 2017*** | | | | | | | |
| 1 | 286 | 34195 | 0.99 | 587 | 364 | 27.62 | 579 |
| 2 | 288 | 34195 | 1.01 | 585 | 364 | 27.20 | 593 |
| 3 | 295 | 34412 | 1.01 | 583 | 368 | 28.28 | 584 |
| 4 | 295 | 34630 | 1.01 | 584 | 368 | 27.67 | 597 |
| 5 | 301 | 34412 | 1.00 | 607 | 366 | 28.01 | 601 |
| ***Mean of All Years*** | | | | | | | |
| 1 | **263 B** | 33977 | 0.99 | 561 | 35.5 | 27.25 | **543 B** |
| 2 | **281 A** | 33686 | 1.00 | 595 | 35.7 | 27.05 | **583 A** |
| 3 | **280 A** | 33614 | 1.00 | 593 | 35.6 | 27.61 | **570 AB** |
| 4 | **281 A** | 34122 | 0.99 | 599 | 35.1 | 26.91 | **585 A** |
| 5 | **280 A** | 33832 | 0.99 | 594 | 35.7 | 27.10 | **578 A** |

***Column data followed by different levels are significantly different at P<0.05.***

All treatments received the same amount of nitrogen and phosphorus fertilizer (220 lbs N/acre and 40 lbs P/a, respectively), but Treatments 4 and 5 missed a 25% addition of fertigated zinc at the 11 leaves to tasseling stage in all three years of the study.

Overall grain yields were excellent (Table 2) and although there were no statistically significant differences (P<0.05) in yields in individual years, there was a strong numerical trend for greater yield for inseason phosphorus fertigation. When the data was analyzed over all three years, there was a statistically significant grain yield increase with inseason phosphorus fertigation. There were no significant differences in crop water use, but water productivity was significantly greater for inseason phosphorus fertigation when averaged over the three years. There was no appreciable effect of how the fertigated phosphorus was applied within the three growth stages.

## Fertigation is a Useful Addition to Intensification of Crop Production with SDI

A new SDI study was initiated in 2017 at the KSU Northwest Research-Extension Center at Colby, Kansas to evaluate the potential of increasing crop water productivity through intensive management of crop inputs. Fertility management was the same across all treatments but included inseason fertigation of all three macronutrients N, P and K along with some zinc applied at planting. Study variables were 3 irrigation levels (designed to meet 85, 100 or 115% of the ETc minus precipitation requirements), 2 high-yielding corn hybrids (Pioneer 1151 and Pioneer 1197) and 3 plant densities (34,000, 38,000 or 42,000 plants/acre). Yields were exceptionally high in this study in 2017 (Table 3).

**Table 3. Corn yield and water use parameters in an SDI study with intensive management at the KSU-NWREC, Colby, Kansas in 2017.**

| Main Effect | Grain yield (bu/a) | Plant Density (p/acre) | Ears /Plant | Kernels /Ear | Kernel Mass (mg) | Crop Water Use (inches) | Water Productivity (lb/a-in) |
|---|---|---|---|---|---|---|---|
| ***Effect of Irrigation Level*** | | | | | | | |
| Irr 1, 115% ETc *(16.75 inches)* | 293 | 37679 | 1.02 | 587 | 33.3 | **29.19 A** | **563 C** |
| Irr 2, 100% ETc *(14.50 inches)* | 292 | 37716 | 1.02 | 586 | 33.3 | **27.10 B** | **605 B** |
| Irr 3, 85% ETc *(12.00 inches)* | 289 | 37752 | 1.01 | 580 | 33.6 | **25.50 C** | **638 A** |
| ***Effect of Hybrid*** | | | | | | | |
| Hybrid 1, Pioneer 1151 | **280 B** | 37873 | 1.01 | **556 B** | 33.7 | **26.68 B** | **590 B** |
| Hybrid 2, Pioneer 1197 | **304 A** | 37558 | 1.02 | **612 A** | 33.1 | **27.84 A** | **614 A** |
| ***Effect of Plant Density*** | | | | | | | |
| Plant Density 1, 42K p/a | **296 A** | **41600 A** | 0.99 | **552 C** | 33.0 | 27.35 | 607 |
| Plant Density 2, 38K p/a | **295 A** | **37788 B** | 1.02 | **587 B** | 33.3 | 27.30 | 608 |
| Plant Density 3, 34K p/a | **285 B** | **33759 C** | 1.03 | **614 A** | 34.0 | 27.14 | 591 |

***Data for a main effect within a column followed by different letters are significantly different at P=0.05 level.***

Yields were not affected by irrigation level, which agrees with earlier discussion that SDI levels matching approximately 75 to 80% of full irrigation will maximize yields. Crop water use was affected by irrigation, but this is just reflecting the higher irrigation amounts which probably ended up as increased deep percolation. This is further emphasized by the greatest water productivity at the irrigation level designed to match 85% of ETc minus precipitation. There was a strong hybrid effect on yield (Pioneer 1197 exceeded Pioneer 1151 by 24 bu/acre) which emphasizes that hybrid selection remains an important factor in intensively managed corn. This yield increase for Pioneer 1197 was primarily caused by greater number of kernels/ear. Pioneer 1197 also had higher water productivity than Pioneer 1151, but crop water use was slightly greater with Pioneer 1197. Plant density of 38,000 or 42,000 plants/acre resulted in significantly greater yield than 34,000 plants/acre, but crop water use was not affected at approximately 27.26 inches. Although the lower plant density had greater number of kernels/ear, this value was not able to compensate for the lower plant density. This reflects a growing understanding that maximizing irrigated corn yields often requires maximizing the intermediate yield component of kernels/area (i.e. plant density x ears/plant x kernels /ear).

## CONCLUDING STATEMENTS

When water and nutrients are highly managed for greatest effectiveness, there can be less margin of error. It is important that producers are diligent in observing the corn growth and development and in monitoring the SDI system.

SDI with fertigation can be a viable option for corn production, enhancing the opportunities for wise use of limited water resources and nutrients, and also in protecting water quality.

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