FERTIGATION BOOSTS CORN YIELDS

Experiments Prove Value of Using Subsurface Driplines as Corn Plant 'IVs'

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As their next step in productivity, corn farmers can use irrigation driplines to precisely apply late-season nutrients and drive yield, according to crop expert Fred Below. Subsurface drip irrigation (SDI) can be used almost like intravenous feeding to corn plants' root zones during critical growth stages, explained Below, a plant physiologist at University of Illinois in Urbana.

In experiments with in-season fertigation, yields were increased by an average of 52 bushels per acre for corn and eight bushels per acre for soybeans, Below said. Maximum yield increases were up 30 to 40 percent, depending on variety or hybrid.

"What we've discovered is that the way our system operates, we're better able to manage nutrients late-season to increase yields in a way that we can't do otherwise," Below said. "That's key for us."

Below is known for creating "The Seven Wonders of the Corn Yield World," a popular framework that lists weather and nitrogen as the top two factors affecting crop growth and development. Drip irrigation, which Below calls "weather insurance," touches his top two wonders - but more than 50 percent of yield. Increasing crop yields is also key for the world's population, projected to reach 9.7 billion by 2050. The latest research indicates farmers must increase food production by 25 to 70 percent to meet future world demand, according to BioScience, the journal of the American Institute of Biological Sciences.

"There are two ways to produce more crops," Below said. "Either you farm more acres or you increase the yield on the existing acres." By mitigating stress on corn, "which should never have a bad day for highest yield," drip irrigation is a potential way that farmers can improve yield potential on their existing acres, he said.

Dr. Fred Below
Professor of Plant Physiology
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"Rather than going out and buying more, improve the acres you have. After putting in drain tiles, what's the next thing you could do? You could try and make sure now that you can add water when needed and nutrients as needed." He said the next step - pushing populations for higher productivity - will require supporting extra plants with added fertility and water.

The greatest advantage of SDI, Below said, is using it as a management tool like no other for delivering nutrients."What we've seen with our system in Illinois is we are better able to supplement and manage more plants with fertigation - and we can do it later in the season when it's almost impossible to add a nutrient to a flowering plant. We can put it right into the root system at that time," Below said.

PROVING BIOLOGICAL CAPABILITIES

Below and a team of researchers found in 2015 that corn and soybean yields were increased by using fertigation and foliar protection together. Corn yield improvements by as much as 69 bushels per acre were achieved after fertigation throughout the growing season with nitrogen, potassium, phosphorus, sulfur and zinc. This was across five corn hybrids and four planting populations raised in Champaign, Below said the most benefit came when nutrients were absorbed after the plant started flowering.

"The basic idea is that all nutrients aren't absorbed at the same rate at the same time. And so as opposed to putting them all on the field at once and being done with it, why can't you adjust their availability with the drip system to better manage the plant needs?"

Using fertigation at key growth stages, corn hybrids reached 246 bushels per acre, on average, in plant populations that ranged from 32,000 to 50,000 plants per acre, data show.

USING SDI TO FOSTER ROOTS

In U.S. cornfields, density averages about 32,000 plants per acre. Since 1960, the plant density has been increasing by a little more than 400 plants per acre each year. The maximum plant density farmers can legitimately get away with in a 30-inch row is 38,000 plants per acre, Below said.

In 15 years, the U.S. average is going to be at the maximum, and that is going to necessitate a shift toward narrow rows," he said.

"The future of corn is going to have to be narrow rows to manage a higher density of plants and to grow high-yield corn." But the trend toward increasing population to push yield comes with a caveat: more plants per row result in weaker plants with smaller root systems.

US CORNFIELD DENSITY

Average 32,000 Plants per Acre

WITH FERTIGATION

Yield = 246 Bushels/Acre

69 BUSHELS/ACRE YIELD IMPROVEMENT

After fertigation throughout the growing season

(nitrogen, potassium, phosphorus, sulfur, zinc)

"One of the advantages of going to narrow rows is you're going to be able to increase the population of plants - but they are still going to have a smaller root system. Any time the plant has a smaller root system, it means that it's more subject to water issues, to drought, and it means that you need to do a better job of fertilizing," Below said.

"That's partly where the subsurface drip comes in. Not only can you manage a higher density of plants but you can also overcome this issue that each plant's going to have a smaller root system." He foresees the increasing use of drip irrigation to offset the drawbacks of greater plant density. "Drip irrigation is an efficient way to mitigate the risk, manage more plants and increase yield and farm profitability," Below said.

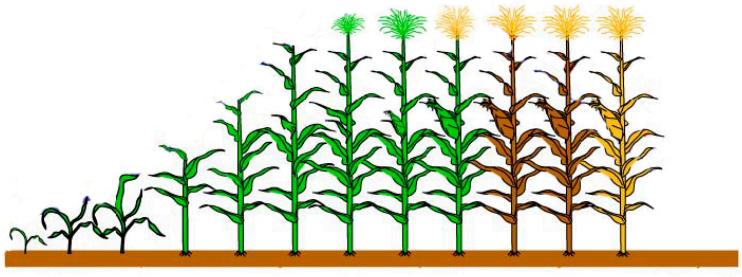
A HARD LESSON REMEDIED

The Illinois experiments also taught a hard lesson: "The disadvantage is that, depending on where the SDI lies buried, you might not be able to deliver the amount of nutrients you need early," Below said.

At the 10 acres of test plots in Illinois, driplines are 14 to 16 inches underground so researchers can do a shallow tillage, Below said. "The roots don't get 14 to 16 inches deep until almost reproductive development," he said.

"When it comes to nutrients, we've discovered that if we have a young plant that's deficient, we have a very difficult time correcting it because our system's driplines are too deep."

What can farmers do in that case? "You have to supply a certain amount of nutrients to the soil in addition to the fertigation. You can't just add everything through the irrigation system. You need a starter fertilizer or something to get the plant off to a good start."



DIFFERENT REGIONS, DIFFERENT NEEDS

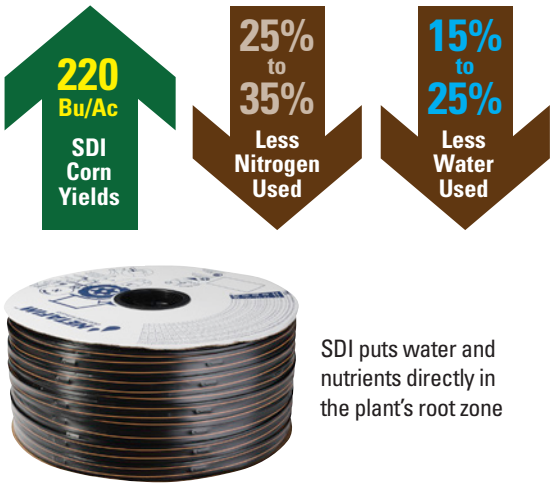
Not all farmers are increasing inputs to boost yield - take Mark Eitel of Dighton, KS. In parched western Kansas, where decades of surface irrigation have depleted the Ogallala Aquifer, Eitel uses a low-pressure SDI system by Netafim.

His entire farm is no till, so he buries his driplines only 12 inches down. Eitel said he uses 25 to 35 percent less nitrogen because he feeds it only as needed through driplines, with his first application when corn plants are about a foot tall. Using SDI for better control over nitrogen timing and placement, he's increased his efficiency across 800 acres as he rotates corn and soybeans, Eitel said.

Despite using less fertilizer, his corn yields have increased from 180 bushels an acre, on average, to 210 to 220 bushels, Eitel said. In one year with decent rain, he applied 147 pounds yet harvested a 265 bushel per acre corn crop, Eitel said. And with SDI, he's using 15 to 25 percent less water compared to other forms of irrigation, Eitel said. That's particularly important in his hot, dry region, where farmers face water restrictions.

"By being able to put the water under the ground where it's never exposed to the sun and the wind, you have a lot less evaporation," Eitel said.

Researchers in Kansas found that with an efficient SDI system, net irrigation needs can be reduced by 25 percent while maintaining high corn yields. Netafim recommends that corn farmers use starter fertilizer, as does Below. Despite those recommendations, Eitel said he's found that his corn does well without starter fertilizer.



SDI puts water and nutrients directly in the plant's root zone

He attributes that to using driplines to inject fertilizer into corn root zones when plants are only a foot tall and roots about a foot long. He said his no-till, holistic system keeps levels of organic matter high and may be a factor in why he's getting by without starter fertilizer.

Below explained the differing nutrient needs between rain-fed areas and Eitel's arid climate: "The reason he can use less fertilizer in western Kansas is that water and nutrients go hand-in-hand, and when he had enough water, the nutrient got to the root. So he could use less. It's different if you have abundant water," Below said, noting that rain washes away mobile nutrients like nitrogen and sulfur.

"Obviously, in the rain-fed areas, it's not necessarily about making sure you have water," he said of drip irrigation. "It's weather insurance, if you will, but more about a new way to deliver late-season nutrient applications."

FARMERS SELL YIELDS

U.S. farmers continue to lead global corn and soybean production as well as yield. They harvested record-high yields in 2016 with an estimated at 174.6 bushels per acre. That's 6.2 bushels above the 2015 average yield.

Still, there's plenty of room to improve the yield gap, Below said. He pointed to the 2016 National Corn Growers Association yield contest. Yields averaging more than 375 bushels per acre were verified with 18 winners in six production categories.

The highest yield was 521 bushels per acre, and the world record was 532 in a 2015 crop. All the winning crops were irrigated. Many farmers wonder just how much those winners spent on inputs to get those super yields. And what's cost effective for the typical farmer to invest on inputs?

"Most growers would make an investment into fertilizer or an input if it had a pretty reasonable chance that it might increase yield and the yield increase is going to be worth more than what they would have to invest into it," Below said.

Installation of SDI can cost up to double that of other forms of irrigation, so farmers must weigh that investment against yield gains, more efficient water use and other factors.

Just as weather brings uncertainty to farming, so can fertilizing. Drip irrigation, however, brings more precision to watering and fertilizing than any other practice, according to Netafim, world leader in irrigation technology.

"The way that we fertilize, it's a messy business with a lot of uncertainty," Below said. "There's a lot of weather impacts that can cause it to be lost, or as in Kansas, unavailable because it's too dry. Fertilization is an imprecise science, clearly, and any way that you can make it more precise has to be better."

THE SEVEN WONDERS OF THE CORN YIELD WORLD

Dr. Fred Below
Professor of Plant Physiology

The seven wonders are shown in the chart on the right and they are ranked in order from the factor with the greatest impact on yield (Weather #1) to the factor with the smallest contribution to yield (Growth Regulators #7). The values represent a range of responses based on our research.

For more information visit:
www.cropphysiology.cropsci.illinois.edu/research/seven_wonders.html

THE SEVEN WONDERS OF CORN YIELD WORLD

RANK	FACTOR	VALUE BU/ACRE	VALUE %
1	WEATHER	70+	27
2	NITROGEN	70	26
3	HYBRID	50	19
4	PREVIOUS CROP	25	10
5	PLANT POPULATION	20	8
6	TILLAGE	15	6
7	GROWTH REGULATORS	10	4
	TOTAL =	260 BU	100%