Science Societies

Could tile drainage be another form of crop insurance in a changing climate?

By Megan Sever

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Double pump lift station. Photo courtesy of Tom Scherer.

Tile drainage can prevent fields from being too wet but can also help when fields are too dry. With “controlled tile drainage,” you capture water when there’s too much of it and store it for later use when there’s too little. This article provide a brief primer on tile drainage, what to think about when designing a system, and how to evaluate whether its right for you the producers you advise.

It may seem odd to be talking about installing tile drainage to prevent fields from being too wet while coming off a year in which most of the Northern Great Plains experienced drought. After all, by summer 2021, Montana, Minnesota, Alberta, and Saskatchewan were in extreme to exceptional drought (that’s the worst category on the drought scale). By the end of September, 97% of Alberta’s agricultural land was in moderate to severe drought and 100% of Manitoba and Saskatchewan’s was in moderate to exceptional drought. Winter rainfall helped some, but by January 31, 2022, half (or more) of Alberta, half of Saskatchewan, and close to two-thirds of Manitoba were under some drought conditions—that’s all land, not just agricultural. Through mid-March, half of North Dakota, most of South Dakota and Kansas, plus every county in Nebraska, Wyoming, and Colorado were under drought conditions.

So why talk about tile drainage when it's primarily used to quickly remove excess water from the plant root zone? Because one form of tile drainage—called "controlled tile drainage"—could be used to mitigate drought as well. You capture water when there's too much of it and store it for later use when there's too little. One system, then, could deal with the vagaries of the weather. And in a changing climate, where extreme precipitation events are predicted to be the norm, who wouldn't want a system that could help solve the age-old problem of farming: making sure there's enough, but not too much, water when and where you need it.



Tile consists of 3- to 15-inch-diameter pipes, usually made of perforated plastic piping (PVC or corrugated). Photo courtesy of Mitchell Timmerman.

A Tile Drainage Primer

Extra water sitting on the surface or in the soil just below the surface creates poor growing environments. We're all familiar with brown, wilted, almost melting, leaves of a plant that's been overwatered. Excess water plugs up soil pore space, preventing oxygen from reaching roots; causes surface runoff, contamination of surface water resources, and accumulation of excess water-soluble salts and sodium (which causes sodicity due to shallow groundwater depths); and prevents contaminants from filtering out of the soil, says Naeem Kalwar, an extension soil health specialist at North Dakota State University (NDSU). Kalwar runs a multi-year tile drainage research program at the university. Commonly, farmers use surface drainage like ditches along headlands or within fields to remove excess water.

But tile drainage systems, which drain excess water through the subsurface, offer benefits beyond what surface drainage systems offer. They're more effective at draining fields, for one thing, says Simon Knutson, owner of Northern Plains Drainage Systems in Manitoba and a professor at Olds College in Alberta. For another, he says, subsurface drainage is more responsible than uncontrolled surface drainage. Using tile drainage, excess water runs off a field far slower than it does with surface drainage. By controlling the water flow, tile also has long-term yield benefits, Knutson says. Studies suggest a 25% yield increase in a tiled field is common (usually over several years). Avoided yield loss is even more common.

Tile drainage, under favorable conditions, can provide more water and crop management options, Kalwar says, allowing for, say, removing excess water in the spring and thus allowing earlier access to the field and earlier planting, or removing excess water in the fall after a heavy storm that would either drown a crop or otherwise prevent a farmer from harvesting until the field dried out. In this way, tile lowers crop production risks, he says. That's important as the Northern Plains of Canada and the U.S. are both starting to see heavier rainfall events more often.

Under good soil water infiltration and permeability, tile drainage also lets farmers maintain groundwater depths at desired levels, Kalwar says. That not only helps prevent root rot and other diseases, but it can also allow for leaching and removal of excess water-soluble salts from the soil, Kalwar and colleagues noted in a 2020 report on their research.

And, through special controlled tile drainage systems, farmers can also use tile to collect water when there's excess, like in early spring, and store it either in the field as subsurface water—like an artificial water table—or in reservoirs for use later in the summer when rainfall is sparse.

It’s not a panacea though, Kalwar cautions. Tile won’t work in every situation, and it’s expensive to put in and maintain. Installation costs average $600 to $1,500 per acre, he says. It’s a big investment. But if designed and installed properly, with the right soil tests and sampling done ahead of time, it should last decades.

Designing a System



Tile drainage helps in fields or parts of fields where the water table rises close to the surface. Tiles are installed 3 to 4 ft below the surface, and water drains to an outlet, where it flows into ditches or streams. Occasionally, the elevation of the water outlet is higher than the elevation of the main tile drainage system in the field, so a pump station is used to lift the water to the surface drain. Photo by Naeem

Kalwar.

Though no two tile drainage systems are the same, basic components are consistent, Knutson says. Every system needs to have one or more outlet points where the water drains from the field; that's the most important part of the system, he says. From a design perspective, you start with the outlet point(s) and work backward. Outlet points can be drainage ditches, natural creeks, even reservoirs—really any place with moving water, notes Tom Scherer, an extension agriculture engineer at NDSU.

Next, every system has what's called "tile" itself: 3- to 15-inch-diameter pipes, usually made of perforated plastic piping (PVC or corrugated) though it could also be made of clay tiles or concrete. The piping is then laid in lines between 20 and 60 ft apart, 3 to 5 ft deep beneath a field, with connecting pipes laid in between. The distance between pipes is dictated by each field's individual characteristics.

Beyond that, systems can include geotextile fabric between the soil and the pipes to eliminate clogging in particularly sandy fields and electric pumps and control structures to help lift water (kind of like a sump pump, Scherer says). Lifts are necessary where topography is an issue, like if a field is too flat and doesn't have a gradient, Scherer says, or where a farmer wants to install controlled tile systems for storage.

Systems can be similar in areas where the site conditions are similar and not complicated, and soils are nearly uniform, says Mitchell Timmerman, an agri-ecosystems specialist at Manitoba Agriculture and Resource Development. Otherwise, he says, there's a lot of variation. In places like western Manitoba, he says, where there's a lot of topographical and soil material variation, systems are complex and unique.

But even if you have a straightforward field, Knutson says, you should start with getting a professional assessment and design from tile drainage specialists. If it's not designed and installed properly, it won't function properly or yield benefits.

Is Tile Drainage Right for My Clients?

You can help your clients to start evaluating whether tile drainage would help them, Timmerman says, by having them ask the following questions:



Tile systems can include geotextile fabric between the soil and the pipes (see tile on the right) to eliminate clogging in particularly sandy fields. Photo courtesy of Mitchell Timmerman.

1. Is excess moisture holding my field back?
2. Could subsurface drainage address the problem(s)?
3. Are the field's soil and landscape properties conducive?
4. Do the designers/installers have all the technical bases covered?
5. Will it pay by making my farm more productive and profitable?
6. What regulatory hoops must I jump through?
7. Do I have local support?

Some entire fields are too wet. Others are mostly fine but have depressions that are permanently wet, Scherer says. If there are spots where a tractor gets stuck after heavy rain, those are places where targeted tile drainage could help, he says. Also, Kalwar adds, if your groundwater depth is shallow, like 1 to 2 ft below the surface during most of the growing season, you may also be a good candidate for tile.



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Whether tile drainage could address the field's problem depends largely on the field's soil and landscape properties. Start with slope. Very steep slopes might be dealbreakers because it's too hard to fight against gravity, Timmerman says. Completely flat landscapes with no gradient are also troublesome, but flat can be worked around, by using a pump system for example. Historically, tile has worked best with 0.5 to 1% slope, he says. The only other "dealbreaker," Timmerman says, is having an impermeable layer at a depth that can't be accommodated. "If the water can't reach the tile, then it's not going to be very effective at moving the water" out of the field, he says. Most everything else can be designed around.

Another problem that might be solved by tile is excess water-soluble salts, Kalwar says. Maybe there are areas in a field where everything grows but another area where nothing grows; it could be salts at the surface or sodicity, for which there are usually no clear visual symptoms. Salts can be helped by tile, but it's not clear yet whether sodicity can be helped by tile alone, he says. Sodicity can also result in dense soil layers above or around the tiles, which can greatly slow down the excess water movement into tiles leading to drainage failure.

To determine if a field's soils may be conducive for tile, start with the internet, Kalwar says. In the U.S., go to the USDA-NRCS's Web Soil Survey (

https://websoilsurvey.sc.egov.usda.gov/) or look at county soil survey maps. In Canada, start with the Canadian Soil Information Service (**https://sis.agr.gc.ca/cansis/**) or provincial maps. Every soil behaves differently. Super sandy soils, for example, aren't great for tile because they clog up pipes. (This can be worked around using geotextile fabric.) Super clayey or silty soils can be problematic because they are less permeable, so it's harder for water to infiltrate through to the tile. (To a degree, this can also be worked around.) But if you have sandy or clayey soils, or soils with sodium-affected subsoils, then you need to run a full analysis before designing a tile system, Kalwar says.

Start by collecting zone soil samples for each field you're interested in tiling, and send the samples to be tested and analyzed in a soil-testing lab for thorough analysis, Kalwar says. Even within the same field, salinity and sodicity levels and other properties will vary. "Evaluating soils for subsurface drainage suitability prior to installation can reduce the incidence of poor tile performance and unrecoverable installation costs," he wrote in his 2020 report.



For each field you're interested in tiling, start by collecting zone soil samples and sending them in to be

tested and analyzed in a soil-testing lab for thorough analysis. Here, Naeem Kalwar collects samples in an unproductive saline and sodic area. Photo by Katelyn Landeis.

You need to know the soil texture, level and composition of soil salts, level of sodium causing sodicity, the overall composition of soil minerals (soil chemistry), and the depth of groundwater to design the right tile system, Kalwar says. Tell the lab you need to know the soil chemical characteristics, especially the sodium adsorption ratio and the electrical conductivity by using the "saturated paste extract method," he says. Evaluate soils to the deepest depth of tiles, which is generally up to 4 ft deep, and ideally, in successive 1-ft increments. (Tile usually sits in the 3- to 4-ft depth range but can go as deep as 5 ft if needed for gravitational flow purposes.)

The soil-testing lab results won't tell you whether a field should or shouldn't be drained, Kalwar notes. However, it will reveal potential challenges and help producers make informed decisions.

From there, producers should consult tile drainage companies, which should do the necessary testing to determine the best design for your client's problem in their field. Some companies are full service, even helping with permitting, Knutson says. Others provide consulting to help farmers who want to install their own systems. If its a small project, Knutson says the best option may be for the farmers to do it themselves after getting some design consultation help. Some universities like NDSU also offer short courses on tile drainage design systems that can help the DIYer.

The first piece of any design is an elevation survey, Knutson says. Typically, high-accuracy GPS equipment would be used to survey the whole field to get "some very, very accurate elevation maps of the fields and where the water's going when it leaves the field." For example, he says, what if a water outlet is uphill? You can still use tile

drainage “but it gets more difficult, more expensive … [you’re] looking at pumping systems, having to bring electrical service to the field.” You “cannot eyeball it,” he says. “I’ve been on so many fields where you would bet your house that the water goes one way, and then you actually find that it goes the opposite way.”

Another thing to consider, at least in Canada, before a lot of time and money is spent on the design is whether the project is actually going to be permitted, Knutson says. Every time you move water, you need permits or licenses, he says. That can take years. Getting a permit involves multiple steps—sometimes even putting up a notice in the local post office telling everyone that you’re planning on releasing extra water, he says. “As you can imagine, that creates a big storm. It’s probably the biggest barrier right now” and why uptake of tile drainage has not taken off like it could. Ideally, installers should help farmers through the regulatory process, Timmerman adds.



Tile installation costs average $600 to $1,500 per acre, but if designed and installed properly, with the right soil tests and sampling done ahead of time, it should last decades. Photo courtesy of Simon Knutson.

The U.S. has fewer regulations. Depending on your location, you may need to notify the local water resource board or downstream neighbors and landowners. Local buy-in is important as is being a good neighbor, Timmerman says. Neighbors are often afraid that if tile is installed next to them, their fields may be inadvertently flooded through the release of more water. The thing is, Knutson says, tile predominantly changes the rate, not the amount of water, that moves through a system. So if you have a heavy rainfall, instead of all the water rushing out immediately in a surface drainage ditch, about half

might flow at first, and the rest will slowly filter out over a couple of days. In that way, tile probably actually makes you less of a nuisance to your neighbors than without it, he says.

Finally (or maybe first?), producers will want to determine if installing tile drainage is a good financial decision. It's expensive. And the return-on-investment period can be as many as 10 or 12 years (or as few as one year), depending on the weather, soil chemistry, crops, and fields. Once or twice a decade, on average, the weather is so wet that everyone loses everything, Knutson says. If farmers put in tile and save their fields instead of losing the entire crop, they've made a wise investment.

There are also tax benefits as tile drainage systems are considered home improvements in the same way a new roof or siding are. And in Canada, some government programs offer loans to help farmers pay for these systems. The Tile Loan Program in Ontario is one example. In addition, you don't have to install tile in all your fields at once. You can do it piecemeal, adding it to one field or a part of one field and maybe later to another field.

An Insurance/Mitigation Plan

Tile drainage systems are but one tool in the farmer's toolbox, Kalwar says. Use it when you need it, if conditions are right, he says. Producers should do their research first, Scherer says, and make sure a system is designed for the needs of their individual field.

If, however, tile drainage in the form of controlled tile drainage (sometimes called "conservation drainage") can alleviate the problem of too much water in the spring and too little later in the summer, it could be a great tool, Timmerman says.

The Northern Plains are fascinating and challenging, Timmerman says. Because of "nature's pause—four to six months of winter"—the region has a short growing season and diverse crop rotation. "We have extremes of excess moisture—major flood events—and then other parts of the province have full-on drought," he says, even in the same year.

Mitigating those challenges would be tremendously helpful for Northern Plains farmers, Knutson notes.

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