ALFALFA ON SUBSURFACE DRIP IRRIGATION (SDI) – PROS AND CONS

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ABSTRACT

Early adoption of subsurface drip irrigation in the United States arguably took place over forty years ago. In that time, the process has become much more refined in large part due to innovation in drip products and the knowledge obtained from early adopters and researchers. These early systems typically consisted of light walled drip tape developed for above ground applications, often installed without flush manifolds, adequate vacuum relieve valves or pressure compensating emitters that are common throughout the industry today. With no effective ability to flush sediment from the drip lines, as well as emitter openings that were susceptible to root intrusion, it was considered to simply be a matter of time before the distribution uniformity of the irrigation system would be compromised. Life expectancy was often estimated to be short lived…certainly less than ten years.

Buried systems of today have emission devices and flow paths designed specifically for subsurface applications. The ability to flush sediments and impurities with proper velocity at each individual zone is now commonplace. Air relief, pressure sustaining and/or reducing valves are incorporated when needed, filtration systems and flush lines properly sized and installed, as well as water quality maintained to increase system longevity and distribution uniformity. If properly maintained, these systems can and have performed effectively far beyond those early expectations of half a dozen years, with proven life spans of ten, fifteen, twenty years and beyond. Creating a much more viable option for those wishing to adopt the technology.

Subsurface applications continue to have obstacles. The majority of which can be overcome to allow for increased efficiencies in water, soil, and plant nutrition…contributing to better plant health, higher yields and an increased return on investment under SDI. The key of which can be planned for through a deep investigation of pros and cons to subsurface drip irrigation in advance of adopting the technology. To benefit from the advantages of applying water directly to the active root zone, rather than simply overapplying water to the soil surface in the hope that the proper amount of water will infiltrate into the soil profile, growers must learn to manage these systems properly. Adopting or changing cultural practices to better align with the newly incorporated ability to apply water directly to the soil profile is an important step in realizing the benefits of SDI systems on alfalfa.

As such, this paper provides an overview of key points related to the Pros and Cons of subsurface Drip Irrigation (SDI), specifically related to alfalfa production. It is intended as an introductory overview for those interested in gaining a basic understanding of the considerations

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necessary prior to installing an SDI system on alfalfa. Each of these topic areas can and should be explored further. Experienced professionals can assist producers as they explore options specific to their individual operations. Readers will gain a greater understanding of key considerations to subsurface drip on alfalfa.
Key words emboldened:

Alfalfa on Subsurface Drip Irrigation (SDI) – Pros and Cons

Increased efficiencies:
The idea behind drip has always been to place the precise amount of water at or near the root. Decreasing evaporation and soil erosion, while simultaneously allowing for the spoon feeding of water and other nutrients directly to the root zone…**increasing efficiencies** and **sustainability** factors. In most SDI applications, irrigation water never actually reaches the soil surface, further **reducing evaporation**, waste and weed pressure. As irrigation water is applied with much greater **precision**, inadvertent leaching can be managed much more closely to conserve precious resources. All the while, increased precision in the application of water supports improved crop health and yield.

Nutrients:
SDI allows for nutrients to be **spoon fed** directly to the effective root zone, providing **timely** delivery and uptake through the root system, **reducing leaching** of nutrients below the root zone, often resulting in reduced **application rates**. As these nutrients are transported via water infiltrating the soil profile, **insufficient irrigation** can leave soil dry between lateral drip lines creating uneven **distribution** of needed nutrients. Thus, to maximize resources, close crop analysis and management tools such as soil moisture monitoring are imperative to understanding crop needs and nutrient movement in the profile.

Energy:
SDI systems are considered **low-pressure** closed systems utilizing a mere eight to twelve pounds of pressure at the tape, resulting in a reduction of **energy usage** as compared to high pressure irrigation systems. However, sand-media filtration pressure requirements are often in the 40-psi range, along with pipe sizing and distance requirements dictating higher pressure needs. Thus, drip does not always present the low energy cost option. Generally, drip is a higher energy user than flood irrigation systems, but lower than that of pressurized sprinkler systems, so energy savings may be negligible and **site specific**.

Plant longevity:
Irrigation cycles for non-SDI alfalfa fields often have an approximate two-week time interval between applications, as the time between laying down the crop and bale removal is not conducive to a quick irrigation schedule. SDI allows many growers to shorten this time frame down to a 7 – 10-day cycle. This may seem insignificant, but this shortened cycle allows for the alfalfa plant to **recover** and begin regrowth much more quickly. Keeping the crop more closely aligned with desired cut and **regrowth cycles**, increasing **plant health** and the potential for higher **yield** and **quality**. Some growers have even experienced an ability to keep their SDI alfalfa fields in production longer than they had experience in flood operations.

Soil characteristics and topography:
Soil characteristics play an important part in drip design, as understanding the likely **movement of water** through the soil profile is hugely impacted by soil type. Drip designers closely evaluate soil data to better select proper drip lateral spacings, depth, zone size, emitter spacing and flow rate. In the case of soils that are more susceptible to **compaction**, this may dictate the need for precision insertion of drip line laterals to allow for deep ripping operations. At 40," the most common tape spacing for alfalfa adapts well to this scenario. Although, SDI users commonly experience a more mellowed soil condition over time due to the sub-terranean nature of SDI, rather than the compaction realized from above ground applications of irrigation water, compaction remains an important consideration.

Additionally, the feast or famine cycle of **flood irrigation** operations can reduce soil permeability, **reduce oxygen** movement in the profile for periods of time while flooding out crop stands at the lower end of the field and eroding vulnerable soils. All of which negatively affect soil, plant health and yield. Irrigation **timing** must be aligned with field operations, allowing heavy equipment to enter the field without damaging drip lines. Well managed SDI systems commonly lead producers to find that they may very seldom or no longer need to deep rip subsurface irrigated fields

Changes **in soil type** often relate closely to changes in topography, traditionally known to be an obstacle for drip systems, as slight hills and valleys would cause fluctuations in both pressure and flow. Today, **pressure compensating** emitters can help to overcome these changes in elevation to provide a more even distribution of water. Although extreme topography continues to limit SDI adoption in some cases, these subsurface systems do allow producers to recapture unproductive ditches, roadways, pivot tracks and more. Still, drip tape is predominantly installed uniformly throughout a particular field, although its consistent flows may not match the wide variation of water demand based on soil properties throughout that certain field…an issue common to all forms of irrigation.

System cost:
Initial cost of SDI systems can easily exceed $2,000.00 per acre. For producers accustomed to flood irrigation, with virtually little cost above that of the water itself and its delivery to the field, an SDI installation can appear to be overwhelming. **Analysis** must be done on a case-by-case basis to better understand the potential for return on investment through increased **quality and yield**, water and fertilizer **efficiencies**, improved plant health and longevity as well as labor savings. There is no one-size-fits-all approach to understanding system cost or **return on investment** for SDI systems. It deserves deeper consideration than a simple glance at initial cost. With a verified useful life of a decade or more and reports of systems in use beyond 20 years, these systems can amortize well. However, quality design, product and installation should not be sacrificed to meet low budgets and above all **maintenance** remains paramount to system longevity.

Labor:
Labor costs and the scarcity of **skilled farm workers** is an ever-increasing issue in the ag industry. As a result, SDI systems are often seen as labor savors when compared to most forms of irrigation, especially with fully automated SDI. Automated or manual, these systems take

very little labor to manage. However, **installation** is very **labor intensive** and although some producers choose to install on their own, it is often recommended that producer's contract with an experienced local provider for at least their initial installation.

Qualified dealer:
Transition to subsurface irrigation has a **substantial learning curve**, especially when compared to that of a flood system. The key is to find a good consultant, extension agent, supplier or other professional who can provide guidance. A solid **service provider** can deliver valuable experience and advice to a new user. With variables from soils, topography, crop, environmental conditions, to water quality and flow the learning curve is substantial. Beyond the trusted advisor or dealer, the producer must take an active role in the management of the system. Knowledge, experience, and on-site evaluation…especially with alfalfa, is needed to establish irrigation schedules. Yet, these systems can be more forgiving than expected due to their timely and precise water application. With a **well-designed** system and a solid advisor, a grower can quickly adapt to the use of an SDI system. Greater grower involvement in planning and implementing system use leads to a smoother transition.

Cultural practices:
Flood irrigated fields commonly have a .5% to 2% downfield slope, which is ideal for the **transition to drip**. However, these irrigation systems should not be scheduled in the same manner. Flood is traditionally a feast or famine approach to irrigation, with common issues such as soil erosion, over saturation of oxygen deprives soils or extremely dry hydrophobic soil conditions. **SDI** is more of a precision application of timely water applied directly to the root zone, so run times and frequency of irrigation is often quite different from flood. Growers will need to **adapt** their cultural practices to SDI systems, rather than employ their old flood strategies. It is critical to have a clear understanding of system capabilities along with specific plant needs. Knowing the hourly application rate of each individual system along with closely **monitoring** the **soil moisture** of the profile will be imperative, as excessive runtimes in some soils can lead to **preferential flows**, which results in poor lateral water movement and reduced **distribution uniformity**.

Germinations:
Most certainly, **germination** of alfalfa seed via SDI systems can be a challenge for producers, due in large part to the shallow depth of newly sewn alfalfa seed and the soft soil structure of the seedbed. Moving water from the buried drip lines to the soils surface is not always possible with SDI. Producers often **surge or pulse** these buried systems to push water laterally, as well as toward the soil surface. Through a series or shorter than normal irrigation events, these stacked irrigations can better fill the complete profile. However, it is not uncommon for growers to maintain some form of flood or sprinkler irrigation capabilities on these fields to overcome this SDI limitation.

Sprinkling up new crop alfalfa provides for a much more uniform germination process. **Pre-irrigating** these newly planted fields through the drip system can help to fill the soil profile ahead of seed drilling as well. However, sprinkling up these plantings remains the most preferred method. For these new SDI plantings, drilling alfalfa seed in the fall months to assist with germination is preferred as a means of utilizing winter moisture to help establish a full profile and uniform crop stand. Lack of doing so often results in an uneven crop stand in the first year or two of production, as plants closer to drip lines flourish, while those located between lateral lines struggle to become established.

Flood and sprinkler irrigation can work as well yet present their own set of challenges in a soft seed bed. Especially, in those cases where field workers must carry-out various duties in these freshly irrigated fields. These irrigation sets will often last 12 hours or more, causing very deep, soft mud in the seedbed. This mud not only makes it difficult to walk or work in fields, but tracks made can leave long lasting impressions, lasting far beyond the season. Additionally, with no plant root structure to hold newly planted seed beds in place, flooded fields become **highly erodible** until full germination and substantial root development takes place. These **germination challenges** must be taken into consideration when designing an SDI system. Many variables should be evaluated; flow rates, lateral and emitter spacings, depth of drip tape, irrigation timing, soil types, etc. There can be germination limitations for other crops as well…especially in regions with historically low spring precipitation.

Root intrusion:
Always a concern on **buried drip**, it is inevitable that roots will search out drip line **emitters** over time. Certainly, maintaining a well irrigated soil profile helps to prevent **root intrusion**. However, periodically throughout the season, alfalfa systems will be shut down allowing the soil profile to dry, causing roots to search for alternative **sources of water**. Additionally, system shutdown over the winter season can provides ample opportunity for **root hairs** to search out water sources…including emitters.

Several steps can be taken to **minimize this risk** to the system, the first of which is to select drip lines that are designed for this type of installation. Most manufacturers have developed heavy walled polyethene drip tape products, some of which have a small flap of material that covers the emission point of the emitter, to make it more difficult for soil particles, **roots** and other **contaminants** to enter the emitter when not irrigating.

Emitters and filter disks impregnated with a **herbicide** have also been developed in an effort to inhibit these root hairs from entering emitters. Released at extremely low levels, these products can impede root intrusion by creating barriers to roots at emitter openings. In other cases, herbicides, chlorine, acid, and other chemicals have been used to hinder, prevent, or destroy these damaging root hairs in or near the emitter. Left unchecked, these tiny roots will likely completely **plug emitter** openings, eventually rendering all or part of the drip lines useless. **Prevention and maintenance** are the keys to **long term success** in SDI.

Rodent control:
Rodents have long been known to have a **detrimental impact** on crops, but they can create even greater havoc to these subsurface systems. So much so, that it is not uncommon for irrigation companies to discourage growers from making the switch to drip prior to getting existing rodent issue under control.

Drip tape is manufactured with different wall thicknesses…measured in milliliters. Above ground drip applications typically use a five or six mil tape, while buried systems commonly use thirteen to fifteen mil. This heavier wall thickness provides **greater system durability** and longevity, through greater resilience against sharp rocks and other objects in the soil profile. In fact, these heavier walled tapes are typically a requirement for most government **cost share** programs funding SDI systems. Additionally, the heavier wall thickness provides greater resistance to an entire host of pests. Producers and drip installers report damage from frogs and crickets, to insects and mice…all the way to **gophers** and the like. Even these fifteen-mil tapes are no match for a gopher, as these and other rodents don't just nibble in one location, they damage tape indiscriminately throughout the field. Sometimes scattered up and down a particular lateral, while in other instances chewing entire sections. Either way, one bite or an entire section chewed, it must all be discovered and replaced.

Repairing these damaged sections is costly. Industry professionals commonly assign a $10.00 - $20.00 cost for each subsurface drip tape repair, the majority of which is the cost of labor to discover and excavate the damaged lines. System pressure drop is the first indication of a leak in the field, while finding an abnormally tall green patch of vegetation or puddled water at the soil surface is simply the first step in locating a leak, as it is an indication of where the water is surfacing. The difficult task is tracing that leak back to the buried line, as the spewing water will often surface downfield from where the subterranean leak occurs. Once found and the soil completely excavated to expose the leak, two couplers are used to attach a new pieces of drip tape in place of the damaged section. Care should be taken to assure that the new section has the proper flow and number of emitters to replace that which was removed. After the soil is carefully replaced and the repaired section of drip line covered, the system should be purged to assure that no soil or other impurities were ingested into the system through the damaged section.

Various strategies are used for discouraging in-field rodent activity. From mowing outer field edges to reduce habitat, to using bates, traps and bounties to keep populations down. Owl boxes are a common strategy to encourage natural nocturnal hunters and it is not uncommon to see bird stands created to encourage hawks and other daylight predators as well. Each of these strategies has its own place in an **Integrated Pest Management Program (IPM**). Including Protec-T, an EPA approved deterrent to gophers in subsurface drip acres. Injected into the enclosed water column and applied through the irrigation system at a rate of one to two gallons per acre, Protec-T can have a significant impact on driving gophers above ground…where predators, traps and other incorporated IPM strategies can have a decimating effect on the rodent population.

Water Quality:

To a large extent, **water quality** is of minimal concern to sprinkler irrigators and often of even less concern to flood irrigators. However, SDI is an entirely different situation, as water quality issues must be discovered and properly diagnosed to overcome potential clogging issues. Bicarbonates, minerals, iron, algae, pH and more can each have denigrating effects on drip systems. Today, there are a wide array of products on the market to help growers battle these water quality issues, along with numerous companies capable of assisting in the diagnosis, prevention, and remediation of these dripline destroyers. The first course of action is always to perform a proper water analysis when evaluating site suitability for subsurface or surface drip applications.

Filtration:

In addition to chemical water treatment when necessary, **water filtration** is of key importance, as emitters are susceptible to clogging due to their very small orifices. Drip line manufactures each have their own recommended specifications for the level of filtration deemed necessary for each product line. One hundred twenty to two hundred (120 – 200) mesh filtration is the common recommendation for drip tape products. This mesh designation is determined by the total number of openings per one square inch. Thus, 120 mesh has 120 openings per square inch. To understand that correlation to particle size; two hundred mesh screens filter down to the approximate width of a human hair, so properly maintained systems can remove much of the clogging potential in the water column.

Once a proper water analysis has been completed, determining the volume and **level of filtration** is the next step, followed by the operation of the filter system itself. These systems are designed to meet specified **flow** and **pressure** ranges. As these filtration systems remove particles from the water column, they begin to increase back pressure, due to the contaminant load captured in the filter unit. These **contaminants** must be purged (**backwashed / flushed**) from the system on a regular basis to assure proper flow. This is often an overlooked detail, but this along with **pressure** must be monitored closely and adjusted to match the filter specifications.

A properly designed and maintained automatic filtration system can run with very little supervision. If flush water can be recaptured, the wastewater can be recycled and utilized, maximizing water efficiencies. If maintained, filter systems have extremely long usable lifespans, spreading the high cost of filtration over many years. Filter systems can often comprise 10% - 15% of the entire system cost. Unfortunately, this causes producers to sometimes look to filtration for cost savings, which is never recommended. Proper filtration is an insurance policy for the entire SDI system. Thus it is not a place to cut corners. Additionally, the dirtier the water, the more contaminants are to be removed from the water column. With this heavier load of impurities comes more frequent backwash (flush) cycles, increasing wastewater and energy consumption, so properly sizing and operation of filter systems is imperative.

What to do with this purged filter water is an issue to overcome right from the start as well. The **effluent** is often pumped into a containment reservoir, diverted directly into the field or even into an open ditch. Depending on the quality of water, these filters can have a significant volume of wastewater, so growers must have a plan for this water.

Flushing the irrigation system:
Flushing or purging a system is not just intended for the filter station itself. Drip systems, especially sub-surface drip systems, should have a regular maintenance program that includes flushing drip lines periodically though the season, as well as after each fertilizer application. This becomes increasingly important when using organic fertilizers, as those products tend to be even more problematic, increasing plugging potential. Although this water has been filtered, there are always small particles (silts, clay and debris) that pass through the filter system and settle in the drip line, dictating the need for a purge of the entire irrigation system.

Yet, simply performing a periodic flush of the lines is not enough, it must be done properly. A lack of proper pressure and velocity will not remove these impurities, so simply opening the end of drip lines will not necessarily remove these contaminants. There must be sufficient velocity to remove the sedimentation. The commonly accepted practice is to flush laterals at a velocity of one foot per second. If too many lateral lines are opened at one time, the velocity and flow are reduced below this desired level…which translates into an ineffective flush. In today's SDI systems these laterals are typically tied into a flush-line at the bottom-side of the field, with two flush-lines per single zone. Each of these lines is then purged independently to assure adequate flush velocity. Proper flushing is imperative to SDI system longevity, so this is a must. Unfortunately, all too often this practice is neglected.

Flow of water:
In addition to a clean water supply, drip systems also require a consistent supply of water. When planning SDI systems, designers commonly divide the total volume of water into multiple zones. These zones are then split into like sized sets, which correlate to the total volume of water available. Commonly, 85% of maximum flow is factored as a safeguard to assure that relatively small fluctuations in available volume will not compromise system performance. Even then, multiple zones are incorporated into each set so that a large fluctuation in supply would still allow a system to operate at proper flows by simply decreasing the number of total zones included in each set. If a zone were designed to take most of the available water, a substantial decrease in flow could render those irrigation zones ineffective. As such, once a system has been designed for a particular flow rate, it is imperative that the system maintain that proper flow and pressure to sustain the designed distribution uniformity of the system

In some areas, another common strategy to drip system design is combining multiple sources of water into on-site reservoirs to allow for a more consistent volume of water. In turn, that flow along with considerations for crop water needs helps to determine drip line spacing and flow. Producers looking to transition to drip should fully consider all possible cropping possibilities. A grower may be planning the system to support a particular crop, but it is often best to create a more versatile system. One that can accommodate various plant row spacings and water demands. Will the row spacing, tape orientation, drip tape depth and flow be conducive to other cropping scenarios? The more versatile the system, the greater flexibility the producer will have to make unforeseen adjustments over time. The key is planning, to create the most adaptable system possible, as once installed there is very little ability to adjust flows upward, as the infrastructure is set in place.

Salinity:
The accumulation of salinity in the soil profile is certainly an issue of concern for producers. Although, some crops are more susceptible to the impact of excess salinity than others. Commonly, SDI users rely on natural precipitation to assist in moving salts beyond the rootzone of a particular crop, but Mother Nature is not always cooperative. As a result, it is not uncommon for SDI designers to provide flood or sprinkler capabilities in these drip systems. For example, in alfalfa SDI designs, some systems will include alfalfa valves or other valve assemblies to allow the producer to attach sprinkler pipe or to simply flood irrigate the crop from time to time. This provides the producer with greater system flexibility for seed germination, as well as the ability to evenly soak the crop surface, allowing water to infiltrate the entire soil profile, forcing salts below the drip lines and active root zone. Without this type of system, it

can be very difficult to push accumulated salts from between the drip laterals and deep into the soil profile. A long-practiced strategy has been to run SDI systems during natural rainfall events to provide greater saturation as well. This creates a better pathway for salts to flow below the root zone through the saturated profile as these salts often accumulate above and between drip lines as normal SDI irrigation events do not typically fill that portion of the soil profile.

CONCLUSION

There are most certainly pros and cost to making the move to sub-surface drip irrigation. Beyond the initial cost of installing an SDI system and overcoming the constrictions of land and water, drip designers can design around most obstacles.

Yes, labor savings can be realized through the move to SDI systems and yield increases often result from the precise and more timely availability of water and nutrients in the active root zone. Reductions in water usage or at the very minimum better utilization of water resources is common as well.

Greater plant health is often seen due to more timely irrigations. In the case of alfalfa, SDI often provides for a shorter span of time between irrigations. Where flood operations often have two-week cycles of feast or famine irrigations, flooding the bottom of fields for much longer than the scheduled irrigation set, while drying out and even creating cracking in the soil profile between irrigation events. Sub-surface drip allows for a shorter time interval between these irrigation events. In turn, this helps reduce plant stress on the alfalfa plant, initiating regrowth more quickly.

The initial keys to system longevity are quality design, components, and installation, along with a solid maintenance program. In the early years of buried drip systems, the common expectation was that these systems would have a useful lifespan of under ten years. Today, SDI systems have proven to have much greater longevity. In fact, with proper maintenance, there is no reason that the useful life of these systems should not be double that of those early systems.

The long-term key to success is maintenance. Producers should monitor pressures and flows from the very first use of the system. Maintaining filtration systems per manufactures specifications is imperative, while monitoring and responding to every-changing water conditions to reduce plugging potential. Assuring that the entire system has appropriate vacuum relief to prevent the ingestion of soil particles upon system shut down is mandatory. Producers must proactively assure that rodent issues are controlled. And last, but not least, purging impurities from irrigation lines through regularly scheduled and properly executed flush protocols must take place.

Investigating whether to make the switch from flood to SDI should most certainly be done on a well-informed, case by case basis. However, there is no reason to have deep concern for the viability of these systems. It is a matter of finding a trusted advisor or dealer and investigating all parameters very closely to evaluate the fit for each application, purchase quality components, install, operate, and maintain the system properly and per specifications.