MOBILE DRIP IRRIGATION (MDI)

Abstract

Mobile drip irrigation (MDI) drags drip tubing with in-line emitters behind a center pivot. This publication describes the advantages and disadvantages of MDI and concludes that growers should consider MDI if they have inadequate water for unstressed crop production *and* field runoff problems that make it difficult for them to use low elevation spray application (LESA) or low energy precision application (LEPA).

What Is Mobile Drip Irrigation (MDI)?

Mobile drip irrigation (MDI) combines the high efficiency of surface drip irrigation with the flexibility, lower hardware costs, and convenience of center pivot irrigation. In this system, the drip tubing is attached to center pivot irrigation systems to apply water directly to the soil surface as the driplines are dragged across the field to create a uniform wetting pattern across the entire irrigated area (Figure 1).

Figure 1. Mobile drip irrigation (MDI) in an alfalfa field. Photo by Troy Peters.

Instead of sprinkler heads or nozzles, MDI uses heavy-walled, in-line drip hoses in place of nozzles or sprinkler heads that are spaced 20 to 40 inches apart (Table 1). Spacing is chosen based on the crop, the soil type, and the rooting depth of the crop. The length of the dripline that drags behind the center pivot depends on the flow rate needed and the area that is irrigated during movement. The length of the dripline is increased (linearly) with distance from the center pivot. This longer dripline applies more water to account for the longer distances traveled by the more distal parts of the pivot, similar to a center pivot nozzle package. Sprinklers can be left in place for a dual-purpose setup that allows switching between sprinklers and MDI.

Netafim and Dragon-Line are two companies that provide commercial MDI components and design services. Netafim refers to their product as precision mobile drip irrigation (PMDI) while Dragon-Line is a tradename used by that company.

History

MDI is not a new technology. Rawlins et al. (1974) were the first to develop and test mobile drip irrigation in California. MDI was later studied by additional researchers like Phene et al. (1982 and 1985), Kanninen (1983), Howell and Phene (1983), and Helweg (1989). These researchers found that MDI caused a reduction in foliar wetting, salt damage, and spray evaporation. Over the past 19 years, MDI has been modified and commercialized. MDI is now considered to be the most efficient method possible for irrigating with a moving irrigation system like a center pivot, linear move, or boom-cart irrigation systems.

MDI Design, Installation, and Costs

MDI systems have longer driplines (with a greater total flow rate due to more emitters) towards the outer end of the pivot and shorter lines towards the center. Installing the MDI system onto the center pivot is not complicated, and most growers could do it on their own after a short training (Swanson et al. 2016; Yost et al. 2019). The required spacing between the driplines depends on the soil type and the crop but usually needs to be between 20 to 40 inches (Table 1). Sandier soils and shallow-rooted crops require closer dripline spacing to avoid water stress in between driplines. Emitters usually have a one- to two-gallon-per-hour flow rate and are spaced approximately every six inches on the driplines (Jones 2015; Yost et al. 2019). The spacing between the emitters can be varied to match the infiltration of the soil. Soils with low infiltration rates (e.g., clay soils) may need longer distance between the emitters to allow a greater amount of time for the water to infiltrate into the soil as the drip tubing is drug over the soil surface. Shorter spacing between the emitters can be used on sandier soils.

There are various ways to connect MDI lines to pivots. Which method is ideal depends on the types of crops in the rotation, row spacing, and row orientations (e.g., circular planting for row crops versus planting in straight lines). For shorter crops, a manifold that is three to four feet from the ground can be used. The driplines are connected to the suspended manifolds which are fed water from the pivot. Alternatively, this manifold can be attached to the truss rods (Figures 1 and 4) or attached to rigid drops (Figures 2 and 3). Rigid drops would be more applicable for taller crops where the dripline riding up high onto the crop canopy might cause uniformity issues. Sometimes the existing sprinkler drops are left in place and remain functional to switch back and forth from sprinkler to MDI to allow the continued periodic use of sprinklers to help with crop germination (Figure 2).

The MDI system needs filtration sufficient for drip irrigation to prevent clogged emitters (Figure 3). The additional filtration can create significant additional costs compared to the mid elevation spray application (i.e., MESA; drops spaced about nine to ten feet apart with sprinklers six to ten feet from the soil surface) or low elevation spray application (LESA; drops spaced about five feet apart or less with sprinklers one to two feet from the soil surface). It is recommended to plant the crop in circles and locate a dripline in between every row, if possible, to ensure equal water to all plants. This avoids potentially damaging the crops by dragging the drip tubing over them. However, circular planting can add additional costs to MDI management (Schmidt and Rogers 2016). This is because planting to align the crop rows with the MDI dripline travel lines can add additional complexity. Circular planting is often done by referencing the wheel tracks and can be greatly assisted by the use of GPS guided tractors when planting. Planting in straight rows is possible with many crops and MDI attachment configurations, especially where the height of the crop will not interfere with the dripline travel location and where the driplines are close enough such that all crops have equal access to water.

Figure 2. An MDI system that uses rigid drops. Photo by Troy Peters.

Table 1. A comparison of the different center pivot water application technologies. Numbers are approximate and can vary significantly.

Pivot Configuration	Wind Drift and Evaporation Losses	Emitter Height from Soil Surface	Sprinkler or Drop Spacing	Wetted Length (Infiltration Time)
Impact Sprinklers on Top of Pivot	40%	15 ft	20 ft	50–60 ft
Mid Elevation Spray Application (MESA)	20%	5–10 ft	10 ft	30 ft
Low Elevation Spray Application (LESA)	3%	1–2 ft	< 5 ft	15 ft
Low Energy Precision Application (LEPA)	0%	0 ft	< 5 ft	1 ft
Mobile Drip Irrigation (MDI)	0%	0 ft	1.5 ft	Up to 65 ft

The costs of an MDI system have been reported to be between $150 and $200 per acre (Yost et al. 2019). If converting from low elevation spray application (LESA) to MDI, costs have been reported to be between $250 and $280 per acre (O'Shaughnessy and Colaizzi 2017).

Figure 3. The filters can be seen on the feed lines from the pivot pipe above. Whole system filtration near the pump is recommended if the entire pivot uses MDI. The ties used to keep the rigid drops vertical can also be seen secured to the truss rods. Photo by Troy Peters.

Figure 4. MDI installed on a center pivot while retaining the sprinklers for switching between MDI and MESA. The driplines on the outside spans of the pivot are longer since it covers a larger area in the field. Although the crop is wheat, the MDI system is set up for taller crops. Photo by Behnaz Molaei.

Reasons to Consider MDI

There are several reasons why a grower might be interested in mobile drip irrigation. These include water savings, reduced runoff, greatly reduced wheel tracking issues, and decreased disease pressure.

Water Savings

MDI is much more efficient than the most common MESA sprinkler configuration on center pivots. The wind drift and evaporation losses of MESA vary with the weather but can average about 20% (Sarwar et al. 2019). However, since MDI emitters deliver water directly to the soil surface, wind drift and evaporation losses are near zero. MDI also does not wet the entire soil surface, so some areas of the soil remain dry. This results in a significant decrease in soil surface evaporation losses after the pivot has passed. Because water is distributed by MDI over a longer time period and the soil has more time to absorb the water compared to MESA, and especially compared with LESA and LEPA, the runoff from MDI is significantly decreased. MDI can also help eliminate overwatering under the inside spans of center pivots, and this can save up to 10% of total water distributed to the system (Du et al. 2011).

A scientific and peer-reviewed research study comparing center pivot sprinkler irrigation to MDI in Germany found a 10–20% (Derbala 2003) and 25% (Hezarjaribi 2008) water savings by using MDI. Another study in Kansas comparing LESA with MDI showed that the soil evaporation component of evapotranspiration from MDI was 35% lower than the in-canopy LESA nozzles (Kisekka et al. 2016, 2017). This is because MDI does not completely wet the entire surface of the soil. There were some MDI trial reports presented by Jones (2015) that found a 31% water savings in Colorado in 2014 and another trial that showed 50% more available soil moisture for crops in Kansas in 2013. In an alfalfa field in Oregon that compared MESA system with MDI, the resulting soil moisture graphs showed that the available moisture at 38 inches under MDI was significantly greater than for MESA.

Energy Savings

Because MDI is more efficient, it uses much less water. In addition, MDI needs lower pressure than sprinklers to operate properly. Lower pressure and less run time can result in significant power savings. Depending on the water source, power costs, and pump efficiency, these power savings alone may justify the conversion of a pivot to MDI. Research studies showed that MDI resulted in energy savings of 20–70% (Lamede 2017), 40–50% (Derbala 2003), or 70% (Hezarjaribi 2008), depending on the particular study and methodology.

Reduced Runoff

One drawback to more efficient sprinkler configurations on center pivots such as LESA is that they have a small wetted radius and water is often applied faster than the soil can take the water in, resulting in ponding and runoff. In addition, the kinetic energy of sprinkler droplets as they hit the soil surface can break up the soil surface structure, create surface sealing, and further decrease infiltration, leading to additional runoff problems. MDI applies the water more slowly along the drip tube as it is pulled through the field (Figure 5). On a typical pivot using a MESA sprinkler configuration, the sprinklers towards the far end of a pivot apply much more water than those towards the inside of the pivot and thus create potential runoff issues (water is applied faster than the soil can absorb it) especially in those areas. However, MDI drip tubing towards the end of the pivot is longer to apply more water making the application rate to the soil the same along the entire length of the pivot. Many growers that have tried MDI have commented on the reduced runoff issues. Some research studies have noted the reduction in runoff in the field by using MDI (Chu et al. 1991; O'Shaughnessy and Colaizzi 2017).

Figure 5. Driplines can be seen throughout this crop. This photo demonstrates that less surface area is wetted compared to sprinklers on MESA systems. Photo by Behnaz Molaei.

Reduced Wheel Track Rutting

Center pivots are heavy, especially when they are full of water. These create large pressures under the tires. Increasingly deep wheel tracks are created as the pivot runs through mud created by the irrigating sprinklers. However, because MDI tubing both drags behind the pivot to some degree and because it applies water directly to the soil, it is easy to keep wheel tracks dry. This greatly reduces pivots becoming stuck in deep wheel tracks, which is a frustrating problem for many growers. In 2017 at Umapine, Oregon, one span of a pivot that was fully converted to MDI was left to run as MESA. The wheel tracks in the MDI system were dry and shallow (Figure 6, right photo) compared to the MESA section (Figure 6, left photo).

In all research studies, MDI has resulted in significantly shallower and drier wheel tracks compared to the MESA, LESA, and LEPA (Jones 2015; Kisekka et al. 2016; O'Shaughnessy and Colaizzi 2017; Swanson et al. 2016; Kisekka et al. 2017; Oker et al. 2018; Yost et al. 2019).

Reduced Disease Pressure

Wet leaves encourage many different diseases including a wide variety of rots, molds, and wilts. MDI does not get the leaves wet, and, instead, the water is applied directly to the soil (Figure 7). This can often result in decreased plant disease pressure, less salt damage to the foliage, or both (Rawlins et al. 1974; Yost et al. 2019).

Figure 6. Even though MDI was available, the span on the left was running continuous MESA sprinklers. Water ponding in the deep wheel tracks is visible (left photo). The wheel tracks in the MDI span in the right photo were shallow and dry. Photos by Troy Peters.

Figure 7. Using MDI on alfalfa in Oregon in 2017. MDI does not wet a significant part of the plant canopy, which makes it easy to walk through and maintain the field as needed. Photo by Behnaz Molaei.

Common Questions about MDI

Can the Pivot Pull the Tubing?

The drip tubing is slick and wet and slides easily over the soil and through the crop. Pivot wheel drives can easily pull the tubing. Even when the drip tubing is attached to the truss rods of the pivot, there were no apparent problems with tilting or excessive torque on the pivot structure. However, it may be wise to be aware of times when the drip tubing may have frozen to the soil surface before starting the pivot.

Can MDI Adequately and Uniformly Irrigate?

Yes, if designed properly. The most important design consideration is probably drip tube spacing, emitter flow rate, and length. Putting the tubes too far apart can result in uniformity issues. Oker et al. (2018) reported that MDI has higher distribution uniformity and application efficiency compared to LESA and MESA. The result of this studies showed that MDI spacing lower than 60 inches resulted in good irrigation uniformity.

Can MDI Increase the Crop Yield?

Since MDI has higher uniformity compared to LESA and MESA, it has the potential to increase yield (Schmidt et al. 2016). There was no significant difference in crop yield, aboveground biomass, leaf area index, or water use efficiency in the research studies compared to MDI, LEPA, or LESA (Kisekka et al. 2016; O'Shaughnessy and Colaizzi 2017; Swanson et al. 2016; Kisekka et al. 2017; Okera et al. 2018; Olson and Rogers 2008). In the studies that compared MDI with conventional sprinkler on the center pivot, like MESA, higher crop yield was observed in the MDI treatments (Jones 2015; Derbala 2003; Hezarjaribi 2008).

Potential Issues and How to Address Them

Though there are many benefits associated with MDI, implementing successful MDI has several challenges, listed in more detail in the following sections.

Plugging

Preventing plugging is very important with any type of drip irrigation, including MDI. Once drip tubing emitters are plugged, there is little to be done except replacing the tubing. In some studies, it was highly recommended to use a filtration system to prevent clogging in the emitters (Derbala 2003; Hezarjaribi 2008; Jones 2015; Yost et al. 2019; Lamede 2017; Olson and Rogers 2008). It is also recommended to open the ends of the drip tubes periodically to flush out sediment that may have gotten past the filters.

Striping or Water in between the Tubing

In sandy soils, with shallow rooted crops, or when the drip tubing is spaced too far apart, the plants in between where the tubing drags through the soil may have less access to water than those directly underneath the drip tubing (Figure 8).

Figure 8. Because the dripline spacing was too far apart, some of the crop was under water stress, indicated by the darker green bands or stripes. Photo by Troy Peters.

Tangling of the Tubing by the Wind

The ability to efficiently apply water under windy conditions is a clear advantage of MDI over MESA. However, the drip tubes can sometimes be blown next to the tower wheels and drive line. When these wheels are rotating it can tangle the tubes around the wheels. To avoid this scenario, it is recommended that extra space be allocated next to the towers to prevent this and to reduce potential for wheel track rutting issues.

Reversing Directions

Reversing the pivot direction with MDI can tangle the lines. Although growers say that untangling the lines does not take long, it can be a diversion from other objectives. Growers also report that this has been much less of an issue when the drip tubing is full of water (while irrigating) than when the lines are empty and therefore light and less stiff. Because of this, MDI may not work as well on a partial circle pivot (wiper).

Limited Ability to Chemigate the Foliage

Fertigation (applying fertilizer through the irrigation system) is simple with MDI (Oker et al. 2018). However, there is limited ability to use MDI to apply foliar chemigation products because the crop canopy does not get wet. If a grower needs to chemigate with the pivot, then leaving the existing MESA sprinkler system intact and operational will allow the conversion back to MESA for chemigation operations (Yost et al. 2019).

Crop Germination

Crop germination of small-seeded crops can be a challenge with MDI, especially on sandy soils or with greater drip tube spacing. If problems with germination are anticipated, we recommend also leaving the existing MESA sprinkler system intact for this important developmental stage (Jones 2015; Yost et al. 2019).

Crop Damage by Driplines

Many growers report that even without planting crops in a circle (the driplines crossed crop rows) they had no problem sliding MDI driplines through the crops and they were not pulling hard or damaging the crops. Lines where the drip tubing slid through alfalfa were visible (Figure 9) but these lines did not persist through to the next irrigation event (Figure 10). However, some growers in Texas mentioned that when the driplines were traveling perpendicular to the rows and being dragged over crop canopies there was limited damage to the leaves and crops (Swanson et al. 2016; Olson and Rogers 2006; Kisekka et al. 2017). It was unclear whether this caused measurable yield loss.

Figure 9. Dripline trace after irrigation with MDI did not persist to the next irrigation. Photo by Troy Peters.

Figure 10. This picture shows a field that had been irrigated using MDI. It is difficult to discern if there is a remnant dripline trace in this photo. Photo by Troy Peters.

Crops Planted in Beds or Hills

Some crops, especially vegetables like onions or potatoes, are planted on beds or hilled rows. There is a lack of data for MDI on these crops, but it is reasonable to expect that MDI can create some additional difficulties as the dripline placement relative to these rows and slopes in the row may cause local dry or wet spots. Additional trials should be done with dripline spacing and placement relative to the rows as well planting layout (e.g., straight and circular).

Animal Damage to Tubing

Some growers report concerns about animal damage to driplines. Some studies in Texas observed bite marks in the tubing in some instances (O'Shaughnessy and Colaizzi 2017; Swanson et al. 2016).

Summary

Mobile drip irrigation is an irrigation method that many growers could benefit from. MDI can get 10–25% more water to the soil per gallon of water pumped than traditional MESA sprinklers. MDI has been found to use less water than LESA and a similar amount of water compared with LEPA, and LESA has been shown to use about 18% less water than MESA. In addition, there was found to be 35% less evaporation from the soil surface compared with LESA after water was applied. The primary benefit of MDI is that the water is applied more slowly over time, giving the soil more time to absorb the water. This means that MDI will have less runoff than LESA or especially LEPA. Growers should strongly consider MDI if they do not have enough water *and* have runoff problems. If there are no problems with runoff, growers will likely be more interested in the lower-cost methods of LESA or LEPA for conserving water.

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