Drainage Water Management Yield Effects and Farm Profitability

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Drainage water management (DWM) is associated with crop yield increases that, under certain conditions, potentially could offset implementation costs and increase farm profitability. Actual yield effects are highly variable and depend on site-specific characteristics. This technical brief presents a summary of observed DWM yield effects based on published literature, as well as a preliminary analysis of on-farm economic benefits.

*Photo courtesy of USDA NRCS

Agricultural drainage systems enabled the conversion of millions of acres of marginal land into highly productive, profitable farmland. This extensive adoption of subsurface drainage also correlated with an increase in nitrate loading to water bodies,[i ii iii iv] contributing to both local and large-scale water quality impairments.[v vi vii] Best management practices (BMPs), such as drainage water management (DWM), could help mitigate some of these negative effects by reducing nitrate losses from farm fields.[viii ix] DWM enables producers to temporarily raise the tile outlet level and decrease drainage water volume.[x xi xii] Researchers estimated DWM could be implemented on 11.9 million acres of cornland in the Midwest.[xiii] Of that suitable land, 7.2 million acres drain to the Gulf of Mexico where excess nitrate contributes to Gulf hypoxia. Nitrate-N loading to the Gulf could be reduced by 114.4 million pounds annually if DWM were implemented on all 7.2 million acres. However, producers have not yet widely adopted DWM. Implementation might expand where the practice can provide economic returns in addition to off-site environmental benefits.

In certain conditions, DWM is associated with increases in crop yields that potentially could offset DWM implementation costs and increase farm profitability. Yield boosts have been observed when the drainage device is adjusted during the growing season to retain moisture in the soil profile, thereby reducing crop stress during dry periods.[xiv] However, field trials indicate the yield effects are highly variable, and additional research is needed to determine long-term averages. Table 1 summarizes published research on DWM yield impacts. In many cases, no statistically significant yield differences were observed between DWM and conventional drainage. Given the variability in results, no conclusive statement can be drawn regarding a typical yield effect.[xv]

Table 1. Observed yield effects associated with DWM for multiple crops and settings. (Adapted from Skaggs *et al.*, 2012)

Reference	Location	Years Observed	Number of Sites	Crop	DWM Yield Effects
Fausey 2005[xvi]	Ohio	5	1	Corn	No effect
		5	1	Soybean	No effect
Poole et al., 2011[xvii]	North Carolina	6	2	Corn	11% increase
		5	2	Wheat	No effect
		6	2	Soybean	10% increase
Delbecq et al., 2012[xviii]	Indiana	5	2	Corn	5.8% to 9.8% increase
Jaynes 2012[xix]	Iowa	2	1	Corn	No effect
		2	1	Soybean	8% increase
Helmers et al., 2012[xx]	Iowa	4	1	Corn	Reduced yield
		4	1	Soybean	No effect
Cooke and Verma 2012[xxi]	Illinois	2	4	Corn	No effect
		2	3	Soybean	No effect
Ghane et al., 2012[xxii]	Ohio	1 to 2	7	Corn	1% to 19% increase in 6 of 9 observations
		1 to 2	7	Soybean	1% to 7% increase in 7 of 11 observations

Factors influencing yield response to DWM included weather conditions, drainage system design, management intensity, and device spacing. Controlled drainage did not boost yields when there was little to no precipitation after the outlet level was raised. In these cases, no water was available to be retained in the soil profile and contribute to enhanced plant growth.[xxiii] Based on this observation, researchers projected that DWM is not likely to have an effect on crop yield when precipitation coincides with plant needs and therefore adequate moisture is available without the assistance of DWM.[xxiv] Maximum yield effects are likely to occur when the growing season alternates between wet periods and moderately long dry periods. Under these conditions, the moisture retained during the wet period could compensate for the lack of precipitation during the subsequent dry period.[xxv] Drainage system design also impacted yield response, and researchers hypothesized the effects might be greater where tile lines are deep and drainage intensity is high.[xxvi] Higher yields also were observed when the control device was adjusted more frequently.[xxvii] Researchers who observed yield declines in the presence of DWM hypothesized this loss might have been mitigated with more intense management of the control device.[xxviii] Larger yield boosts also occurred closer to the control device, particularly if surface elevation increased further from the device.[xxix xxx]

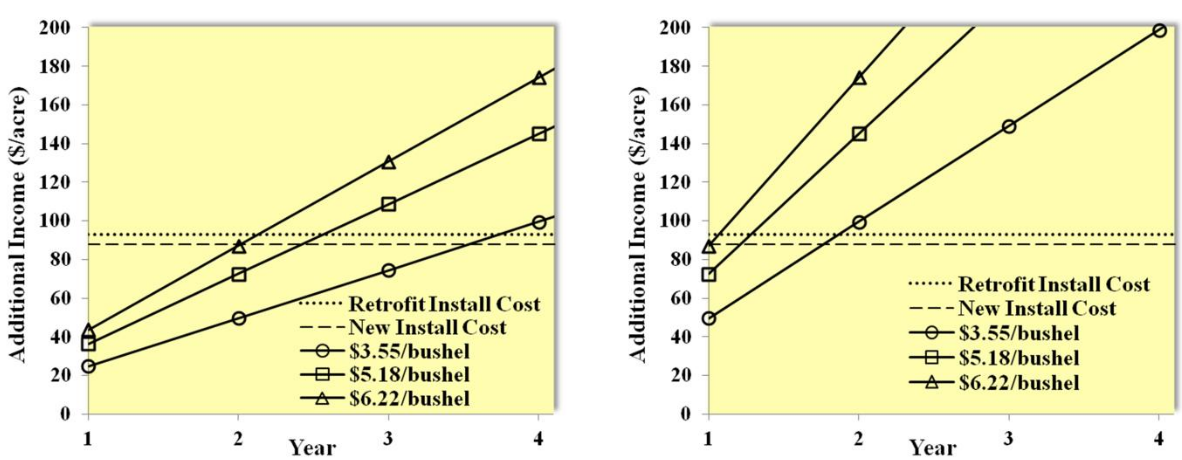
Incorporating subirrigation also is associated with substantial yield boosts. In one study, sites with subirrigation experienced an average corn yield increase of 19 percent and an average soybean yield increase of 64 percent, compared to sites with subsurface drainage only.[xxxi] Another study found subirrigation contributed to a 58 percent yield increase in soybean production, compared to non-irrigation.[xxxii] It should be noted that much of the available published research on subirrigation yield effects was old and there does not appear to have been a strong focus on this practice in the past decade.

Despite recent research regarding yield effects of DWM, there is a limited understanding of how controlled drainage impacts farm profitability. To assess the potential economic benefits of DWM, a preliminary analysis examined the conditions under which DWM might be cost-effective. A break-even analysis estimated the number of years required for a producer to recover the costs of installing a DWM device under several scenarios. This analysis included only the up-front investment cost and did not account for on-going operation and maintenance costs. Estimated costs used in the assessment were $93/acre and $88/acre for retrofit and new installations, respectively. These costs were derived from an analysis conducted by Jaynes*, et al.*[xxxiii]

The break-even point when installation costs would be recovered was calculated for multiple scenarios in corn and soybean production systems. The scenarios represented three on-farm crop prices, three base yields, and two potential yield increases associated with DWM. Yield increases of 5 and 10 percent were applied in this analysis. These yield effects were selected based on a review of observed effects published in peer-reviewed literature. However, the values should not be considered representative, and actual effects will vary. Low, medium, and high on-farm crop prices were selected to represent a range of prices paid to the producer. The corn prices selected were the weighted-average farm prices in 2009/2010 ($3.55/bushel), 2010/2011 ($5.18/bushel), and 2011/2012 ($6.22/bushel).[xxxiv] The soybean prices selected were the average prices received by farmers in 2006 ($6.43/bushel), 2009 ($9.59/bushel), and 2010 ($11.30).[xxxv] Corn base yields were assumed to be 120, 140, and 160 bushels/acre; soybean base yields were assumed to be 32, 38, and 42 bushels per acre.

A graphical illustration of the break-even points for a 5 and 10 percent increase in corn yield is presented in Figure 1, assuming a base yield of 140 bushels/acre. With a 5 percent yield increase, a producer could recover DWM installation costs in four years for both new and retrofit installations at all selected crop prices. With a 10 percent yield increase, a producer could recover DWM installation costs in two years. These years do not need to be consecutive, but rather reflect the number of years in which conditions reflect the necessary factors to achieve a 5 percent yield increase from DWM.

Figure 1. Break-even analysis of DWM installation in corn production assuming a base yield of 140 bushels/acre and 5% yield increase (left) and a 10% yield increase (right) associated with DWM.



Based on this preliminary analysis, yield increases associated with DWM potentially could cover the costs of installing the practice well within the expected lifetime of the device (assuming a 20-year lifecycle). For corn, a producer could recover the cost of installing a DWM device with at most five years of beneficial conditions. In three of these scenarios, a corn producer could recover the installation costs with a single year of beneficial conditions. For soybeans, a producer could recover DWM installation costs with at most nine seasons of beneficial conditions. In three of the soybean scenarios, a producer could recover installation costs with two years of beneficial conditions.

Drainage water management (DWM) can be an effective strategy for reducing nitrate losses from farm fields. In some cases, yield increases associated with DWM might cover device installation costs.

- ***7.2 million acres*** *of Midwest cornland is suitable for DWM in the Upper Mississippi and Tennessee/Ohio watersheds.*
- ***1.43 million acres*** *of this cornland* ***(20%)*** *could be served by retrofits and* ***5.73 million acres (80%)*** *by new installations.*
- ***Retrofit installations*** *are estimated to cost* ***$93/acre*** *and* ***new installations*** *are estimated to cost* ***$88/acre****, with a* ***regional weighted average of $89/acre****.*
- ***Total costs*** *of implementing DWM on all* ***7.2 million acres*** *would be* ***$638 million*** *(****$133 million*** *for retrofits and* ***$505 million*** *for new installations).*
- ***114.4 million pounds of nitrate-N*** *could be reduced if DWM were implemented on all 7.2 million acres.*
- *DWM has been associated with yield increases of more than* ***10 percent*** *for corn and soybeans.*
- ***Increased income*** *from* ***5% higher yields*** *potentially could offset DWM installation costs within* ***5 years*** *for corn and* ***9 years*** *for soybeans, depending on site-specific conditions. These years are not necessarily consecutive but represent the number of years with optimum conditions for DWM to contribute to yield increases.*
- ***Increased income*** *from* ***10% higher yields*** *potentially could offset DWM installation costs within* ***3 years*** *for corn and* ***5 years*** *for soybeans, depending on site-specific conditions. These years are not necessarily consecutive.*
- *Potential on-farm economic benefits could be maximized by taking into account characteristics that influence DWM yield effects, including* ***drainage system design, device placement, and management intensity****.*
- *Additional research is needed to determine long-term average yield effects under various conditions.*
- *Incorporating subirrigation has been associated with greater yield increases than with DWM alone.*

(The nitrate reduction potential and cost values are derived from Jaynes, D.B., K.R. Thorp, D.E. James (2010) Potential Water Quality Impact of Drainage Water Management in the Midwest USA. Proceedings of the 9th International Drainage Symposium held jointly with CIGR and CSBE/SCGAB, June 13-16, 2010, Quebec City, Canada.)

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