

## Crop yield evaluation under controlled drainage in Ohio, United States

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**Abstract:** Controlled drainage (CD) is an important practice for reducing nutrient loading to surface water bodies across the midwestern United States. There may also be a positive crop yield benefit, which could add an incentive for adoption of this practice. The objective of this multi-environment trial was to assess yield stability and yield performance of CD in northwest Ohio, United States. The trial was a split-plot experiment with environments as whole plots (randomization unit). The main plot factor was crop with three levels: corn (*Zea mays* L.), popcorn (*Zea mays* L. var. *evarta*), and soybean (*Glycine max* [L.] Merr.). The subplot factor was drainage management with two levels: conventional free drainage (FD) and CD. The design of the main plot factor was a completely randomized design. Mixed model analysis showed that CD management produced a statistically greater ( $p$ -value = 0.0246) crop yield compared to FD management over 23 site-year environments during 2008 to 2011. Interaction between drainage management and crop was not significant, implying that CD management had the same yield-increasing effect for all crops. The CD management provided 3.3%, 3.1%, and 2.1% greater yield for corn, popcorn and soybean, respectively, relative to the FD management. The stability analysis based on 23 environments suggested that the drainage managements were not different in yield stability, though a larger number of environments are needed to make a more accurate assessment of yield stability. Area of influence analysis indicated that CD can provide more profit than FD for relatively flat fields where the influence of CD extends over the entire field. In conclusion, CD provided crop yield advantage over FD across different environments in northwest Ohio.

**Key words:** free drainage—managed drainage—mixed model—multi-environment trials—on-farm experiment—yield stability

**Northwest Ohio is an intensively drained region within the midwestern United States where excess water in the soil profile is removed to accommodate crop growth (Fausey et al. 1995).** Water quality and environmental concerns associated with conventional subsurface drainage have heightened interest in restricting the subsurface drainage discharge from cropland to reduce the potential of chemical loss (Evans et al. 1995). This practice, which is known as controlled drainage (CD) (USDA NRCS Ohio 2012), may have crop yield benefits. One of the earliest implementations of this practice was in California, United States, where the water table was raised by installing an elbow on the drainage system outlet with the purpose of investigating denitrification (Willardson et al. 1972). Controlled drainage was mentioned briefly in the *Yearbook*

*of Agriculture* (Renfro 1955) as being used in organic (muck) soils with subirrigation and for the control of subsidence (Stephens 1955). Petersen (1966) noted the use of a controlled water table to reduce the presence of iron ochre in drains.

Controlled drainage can retain water in the soil profile for plant growth depending on growing season rainfall, distribution, and crop growth stage. Previous on-station trials (Grigg et al. 2004; Fausey 2005; Drury et al. 2009; Delbecq et al. 2012), and on-farm experiments (OFE) (Cicek et al. 2010) have reported the effect of CD on crop yield. Grigg et al. (2004) did not find a significant corn (*Zea mays* L.) yield difference between CD and free drainage (FD) on a silt loam soil type over a two-year study including both normal and drought years in Louisiana, United States. Fausey (2005) compared corn and soybean

(*Glycine max* [L.] Merr.) yield under CD and FD management on a silty clay soil type over five years in northwest Ohio, United States, and did not find a significant crop yield difference between the two management systems. In Ontario, Canada, the trend was for greater corn and soybean yields for CD compared to FD on a clay loam soil type when using nitrogen (N) fertilizer for both corn and soybean in all four years of the study, but the differences were not statistically significant (Drury et al. 2009). Delbecq et al. (2012) used a spatial panel regression method to analyze yield monitor data and found significant corn yield improvement for CD compared to FD on average during a five-year study at a site in Indiana, United States, with silt loam and silty clay loam soils. In Ontario, Canada, Cicek et al. (2010) found no significant difference in average corn and soybean yield between CD and FD on a silt loam soil type over four years and across four sites using a conventional paired  $t$ -test. However, CD was reported to produce an average of 3% and 4% greater yield for corn and soybean, respectively.

On-station experiments have also reported the effect of CD on crop yield (Wesstrom and Messing 2007; Ramoska et al. 2011). In these studies, observations were comprised of repeated measurements taken from the same experimental unit (i.e., pseudoreplication), which resulted in the lack of independence (Johnson 2006). Therefore, inference of the CD effect on crop yield is questionable due to the lack of true replication and randomization (Piepho et al. 2011). Smith and Kellman (2011) also reported on the influence of CD on corn yield but again without replication.

On-farm experiments have gained interest due to the development of spatially referenced yield monitors where data can be obtained at small spatial resolution (Piepho et al. 2011). Such OFE, when carried out at different locations for several years, can provide

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