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**DRAFT**

*Methodology for meta-analysis of impact of enhanced efficiency fertilizers on corn yield in Midwest*

[Assuming there will be material already written on the database construction]

**Analysis and data**

Data on study results were taken from the database prepared during the systematic review portion of this study (Available in supplemental). All analysis was performed using the R software application (ref). All R scripts for data preparation and calculations are provided in Supplemental information.

**Calculation of effect sizes**

The meta-analysis considered the effect on corn yield of fertilizer with efficiency enhancing products (enhanced efficiency fertilizer, EEF) to the same fertilizer sources without the enhancement products (standard fertilizer, SF). Because all yield measurements were made on the same scale and were of comparable magnitude, the mean difference between EEF and non-EEF treatments was used as an effect size (need ref for these two equations):

**D = X.barEEF–X.barSF**

The variance of *D* was calculated not assuming similar variances for each result mean:

**S2D = S2EEF/nEEF + S2SF/nSF**

The database of studies in this meta-analysis recorded mean and dispersion of results at the level of the individual experimental units, and studies often reported many results representing many combinations of several experimental parameters. The effect size *D* was calculated using two different approaches:

(1) Matching yield results within each study between experiments using EEF and identical experimental conditions using SF (“matched” effect sizes);

(2) Within each study, calculating composite means and variances across all experimental conditions for each EEF versus the corresponding SF source alone (“composite” effect sizes).

Under the matched approach the means of EEF and SF results were matched across 16 experimental parameters: Total N rate, fall N rate, spring N rate, N rate at planting/emergence, N rate for side-dress post-emergence, Second split N rate, third split N rate, application timing, split N applications, fall vs. spring application, N placement, N placement (second), planting date, county, rotation, and tillage.

Composite means were weighted based on number observations in each mean, and composite variances were calculated as the pooled variance of the experimental results:

**S2pooled = Sum[(ni-1) × S2i] / Sum(ni-1)** (necessary to include the standard pooled variance equation?)

Under the matching approach any EEF or SF results reported under identical experimental conditions within each study were also combined using the same compositing approach as above.

A log response ratio was also calculated as an effect size following the two means comparison methods described above (Supplemental).

*Alternate log response ratio approach (Supplemental)*Given that the scale of the effects of EEF might have varied with overall yield levels, a parallel meta-analysis was conducted using the log response ratio (LRR) of yields as a metric of effect size. The LRR was calculated as follows:

**LRR = Log(X.barEEF/X.barSF)**

A positive LRR indicates greater proportional yield under EFF. The variance of the LRR was calculated following Hedges et al. (1999):

**S2LRR = S2EEF/(nEEF ×X.bar2EEF) + S2SF/(nSF ×X.bar2SF)**

*Yield with EEF under lower N conditions*

To specifically analyze the effect of EEF on yield under low N conditions, a separate meta-analysis was conducted using the above approaches restricted to experiments with < 150 lbs. N ac-1. This cutoff represents the approximately lower 60% of experiments recorded in this study with calculable effect sizes.

**Meta-analysis approach**

A random-effects meta-analysis was performed within each fertilizer source/efficiency product combination (ref). The variance of true effect sizes (T2) was estimated using the technique of DerSimmonian and Laird (1986). Weights of the effect size were estimated as:

**1/(S2D + T2)**

The 95% confidence interval of the summary effect of each EEF/SF category was estimated using the Z distribution (ref).

Hedges, L.V., Gurevich, J. and P.S. Curtis. 1999. Ecology 80(4):1150-1156.

DerSimmonian, R. & N. Liard. 1986. Controlled Clinical Trials 7(3): 177-188.