EXPERIENCES IN LOOKING AT PHOSPHORUS MANAGEMENT DATA FOR META-ANALYSIS, CHALLENGES AND DATA GAPS

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ABSTRACT

Phosphorus (P) placement and tillage interactions have been extensively studied for corn and soybean production in the Midwestern states of the US. A meta-analysis was conducted including publications from 1980 to the present with studies in the Midwest region to evaluate the effects of P placement and tillage interaction on corn and soybean yield. Five databases (Wiley International Science, Springer Link, Web of Science, Science Direct, and ACSESS Digital Library) were searched with standard keywords across all database. Coding criteria were set to include site identification information, background soil test, tillage practice, fertilizer P rate, placement, and source, and statistical information. The dataset was evaluated through direct evidence and all comparisons within the database. Preliminary results of direct evidence and all data show generally lower overall yields for no-till for the region of this study. Results suggest no placement effect on yield with the application rates evaluated in this study (> 40lbs P2O5/acre). Band placement may provide a yield increase only if the rates are limiting (<40 lbs P2O5/acre in our study), or in soil testing very low in which the broadcast rate is very low and deficient. Perhaps in this case banding near the seeding could increase yields; additional studies with lower application rates may be required. The largest overall benefit to P placement may come from reduction in runoff loses. Several challenges were identified during the meta-analysis process; many related to the amount and quality of information presented in published papers on this topic. This may require a closer evaluation of current publication guidelines and require support data for peer-reviewed publications.

INTRODUCTION

Crop response and P loss potential can be affected by the interaction between soil and tillage factors with P fertilizer placement. Accurate evaluation of these interactions would require large dataset that comprise a variety of soils, tillage and placement combinations. Meta-analysis is considered a quantitative systematic review of published and unpublished literature/datasets with the use of statistical methods (Philibert et al., 2012; Wang and Bushman, 1999). The use of meta-analysis is relatively new in the area of soil fertility, and narrative reviews has been more common. These narrative reviews are typically subject to the opinion and based on the experience as well as the literature review completed by the author. Meta-analysis can be more powerful than simple narrative reviews, because it summarizes data in a quantitative manner and makes it possible to assess the between-study variability (Doré et al., 2011). However, meta-analyses should be completed following sound methods and quality control (Philibert et al.,

2012). Data can be analyzed as direct evidence, where all treatments are present in one study or by indirect evidence, where studies could only include one treatment.

Some key components of meta-analyses suggested by several authors include: (1) Correct description of the bibliographic search procedures; (2) Listing of the references of the selected individual studies used in the meta-analysis; (3) Analysis of the variability of the results of individual studies, including estimation of variability between the selected individual studies and, when relevant, investigation of the sources of between-study variability; (4) Analysis of the sensitivity of the conclusions to any change in the dataset and/or in the statistical method used to analyze the data; (5) Assessment of the publication bias; (6) Data weighting. When the results reported in the individual studies differ in their levels of accuracy; (7) Availability of the dataset; and (8) Availability of the program used for statistical analysis (Borenstein et al., 2011; Gates, 2002; Roberts et al., 2006; Sutton et al., 2000; Wang and Bushman, 1999).

METHODS

This meta-analysis was developed using the steps described by Philibert et al., 2012, and with especial attention to the quality of the meta-analysis procedure. A database search for all publications that included yield data for corn and soybean was conducted within Wiley International Science, Springer Link, Web of Science, Science Direct, and ACSESS Digital Library databases. The primary search criteria was set to include publications from 1980 to the present and studies conducted in the Midwest or Great Plains region of the US (Colorado, Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Montana, Nebraska, North Dakota, Ohio, Oklahoma, South Dakota, and Wisconsin). This selection criteria limit the geographic region of the studies evaluated, and in some cases may be too restrictive, and may require expansion.

Published articles were selected based on key criteria for quality of information and relevance. Coding parameters were set to include site information (location, state, and study year), background soil (soil series, classification, soil test method, soil sampling depth, STP, and soil test potassium), management practice (tillage type, P fertilizer rate, P application method, and P source), crop information (corn hybrid, soybean cultivar, crop yield means), and statistics (number of replications, standard error (SE), coefficient of variation (CV), and P values). Studies involving manure applications that contained an inorganic fertilizer and control treatments were included in the analysis.

The response ratio was estimated based on the ratio between the response variables (yield) from plots with contrasting treatments (i.e. band placement vs broadcast), and used to evaluate the effect of P fertilizer application under different tillage systems (Hedges et al., 1999). The response ratio was presented primarily as relative responses ([treatment-control)/control] × 100). Statistical analysis was completed using MetaWin and SAS (Rosenberg et al., 2000; SAS Institute, 2010), and following methods described by (Wang and Bushman, 1999). Data was analyzed by STP values above and below 20 ppm using study as a random variable for the analysis. Corn and soybean yield means were weighted based on number of replications. Effects of tillage and P placement on least square means of yields were separated using repeated measure at a significant level of $P=0.10$. Tillage and P placement comparisons were made using least square means estimates.

CHALLENGES AND DATA GAPS

One of the challenges during this meta-analysis was related to the number of studies that meet the established criteria. Perhaps the most restrictive criteria was related to the geographic region selected for our study. The selection criteria for this meta-analysis required studies from 15 US states. A total of 11 states were included (Colorado, Illinois, Indiana, Iowa, Kansas, Minnesota, Missouri, Nebraska, Ohio, South Dakota, and Wisconsin); and 4 states did not meet the criteria (Michigan, Montana, North Dakota, and Oklahoma) (Fig 1). Studies from Illinois, Iowa, Kansas, and Minnesota allowed for direct evidence of tillage and P placement effects on corn yield. Limitations related to the original selection criteria will require an expansion of the search to include more studies; however a very "broad" criteria combined with lack of studies in certain regions can generate wide-ranging conclusions that may not be applicable to certain conditions.

US states considered as seletcion critaria (15) US states that met the selction criteria (11)

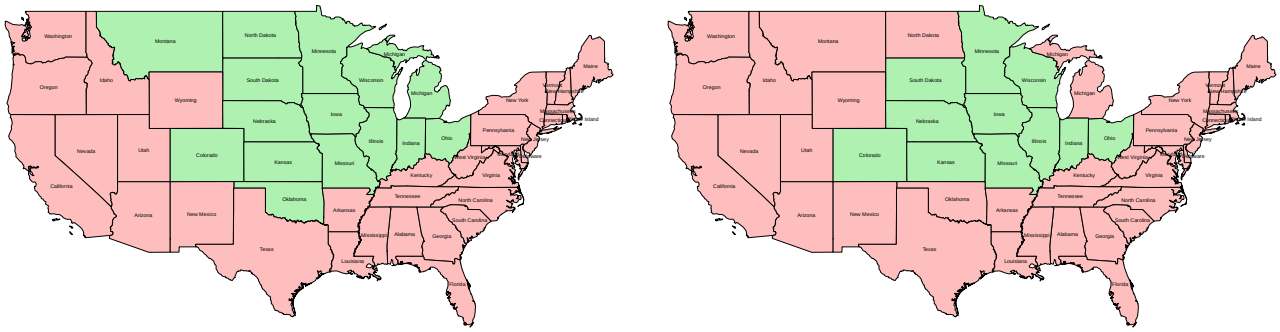

Figure 1. US states included in the selection criteria and states that met the criteria

During the literate search, other issues were identified related to data presentation/availability in peer-reviewed papers, including differences and inconsistences among journals and papers within journals (i.e. background soil information, soil sampling methods and limited detail on fertilizer sources used). Future improvements in data stewardship are clearly needed to increase access and improve the use of published data on this topic. This literature search found that some database (i.e. The Digital Library) are better suited for an effective meta-analysis search.

The specific topic evaluated in this meta-analysis involve factors that have a significant effect after long term implementation (i.e. tillage, fertilizer placement and rates). The large majority of published studies were generated after short term evaluations, and results/conclusions may be different than long term observations. For example, recently completed meta-analysis found that global average yields is lower under no-till system; however the same studies show that the number of years under no-till have a significant effect on yield response (Brouder and Gomez-Macpherson, 2014; Pittelkow et al., 2015a; Pittelkow et al., 2015b). The effect of P placement on yield may be different after long term and continues implementation and with significant vertical and horizontal stratification.

ur meta-analysis found that currently we have limited amount of published work evaluating the long-term effect of specific management systems typically used by producers (tillage, fertilizer placement and the effect on yield and potential P loses to surface water). Research on

certain topics (e.g. tillage), may also need to be standardized to reflect more closely typical management systems used by the producer (Derpsch et al 2014). Furthermore, some specific states in the US have limited amount of published data on the overall topic of tillage by P placement interaction for both agronomic and environmental implications.

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