COUNTY-LEVEL PHOSPHORUS BALANCES FOR 2017 IN ILLINOIS

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ABSTRACT

Cropland phosphorus (P) balances (manure and fertilizer P minus crop P removal) are great sustainability tools to assess long-term managements at farm, county, and state levels. Our objectives were to estimate county, regional, and state-level cropland P balances for Illinois in 2017. Based on the census data in 2017, Illinois county P balance ranged from -16.188 to 38.322 lbs/acre/yr. Overall, Illinois had a negative P balance at about -3.312 lbs/acre/yr. About 76% of counties had a negative P balance, ranging from −0.443 to −16.188 lbs/acre/yr, representing P outputs exceeded P inputs. This could reflect on increased crop yields over time and therefore, greater P removal than expected suggesting modification in P fertilization is required in areas with low P supplying power to sustain P levels at maintenance levels. Future research should focus on evaluating the trends of P balances over the last decade to understand P balance effect on legacy P and P losses in Illinois.

INTRODUCTION

As an essential nutrient to plant growth, Phosphorus (P) has played a critical role in improving crop productivity throughout the last century (Hopkins & Hansen, 2019; Pedersen et al., 2023). Due to its essential agronomic significance in crop production and its underlying harm to the environment when used in excess amount, much research has been conducted on P nutrient balances (Godber et al., 2024). In the last 15 years, there were several studies published on P balances at the US county and state levels (Khanal et al., 2014; Leytem et al., 2021; Peterson et al., 2017). As agriculture dominates land use in Illinois, assessment of P balances will be important for land management and policy development. This study aims to calculate and evaluate the annual P balances (harvested crop P removal subsets P supply with manure and fertilizer) in Illinois at county-level for 2017.

MATERIALS AND METHODS

Data collection and calculation for annual manure P

The inventory of major animals at county level in the state has been considered into calculation for annual manure P. The following categories were used (Mekken et al., 2006): (1) cattle and calves (including beef cows, milk cows, and other cattle), (2) poultry (layers, pullets, broilers, and turkeys), (3) sheep and lambs, (4) horses and ponies, (5) hogs and pigs, and (6) goats. All animal inventory data were extracted from USDA National Agricultural Statistics Service (NASS) Census of Agriculture (2017 Census data). The coefficients for excreted and recovered P were based on Mekken et al. (2006). The annual manure P was calculated as follows (Mekken et al., 2006):

Annual manure P = inventory * P excreted * recoverable P fraction

Where the inventory was the number of animals at county level, and P excreted represented the amount of P in the manure, and recoverable P was defined by the fraction of the total manure P pool which can be managed on the farm (Mekken et al., 2006).

Data collection and calculation for fertilizer P

Fertilizer data were collected from Illinois Department of Agriculture Fertilizer Reports. The amount of fertilizer P at county level was calculated, after the separation of non-farm and farm fertilizer usage, as follows:

Fertilizer P = US ton fertilizer * P_2O_5 *0.437 * 2000

Crop P removal calculation

Data for all crop yields (harvested acres and quantity) at county level were extracted from USDA NASS (2017 Census data). Crops used in this study include corn (*Zea mays* L.), soybeans (*Glycine max* L.), wheat (*Triticum aestivum* L.), oat (*Avena sativa* L.), sorghum (*Sorghum bicolor* L.), alfalfa hay (*Medicago sativa* L.), corn silage, haylage, and other hay exclude alfalfa. Phosphorus grain concentrations for main cash crops (including corn, soybean, and wheat) and crop values (weight per yield unit, dry matter, and P content per yield unit) were extracted from Godber et al. (2024) and Mekken et al. (2006). The crop removal P can be calculated as follows:

P removal in crops = Crop yield * P removed per yield unit

Phosphorus balance calculations

P balance was calculated by subtracting sum of cash crop removal from sum of manure and fertilizer P as follows (Mekken et al., 2006):

P balance (lbs/acre) = [Manure P (lbs/acre) + Fertilizer P (lbs/acre)] - Crop P Removal (lbs/acre)

RESULTS AND DISCUSSIONS

Manure P application

After normalizing data based on the total cropland per county, DuPage, DeKalb, Mercer, Adams, Cumberland, Effingham, Jasper and Clinton County had the highest manure P contribution with 10.511, 10.113, 11.360, 12.952, 11.052,13.589,14.461, and 13.945 lbs/acre, respectively (Figure 1A).

Fertilizer P application

The following counties DuPage, Lasalle, Kankakee, Peoria, Tazewell, McLean, Hancock, Brown, Cass, Montgomery, Clinton, and Edwards had the highest fertilizer P contribution, ranging from 23.717 to 49.014 lbs/acre (Figure 1B). Fertilizer P was applied at higher rates in central crop reporting district, reflecting higher yield potential and thus higher maintenance rates in those counties of central crop reporting district due to greater soil organic matter and tile drainage. P application in the Southwest and

Southeast of Illinois was mostly lower than 10 lbs/acre, reflecting lower expected yields in those areas.

Crop P removal

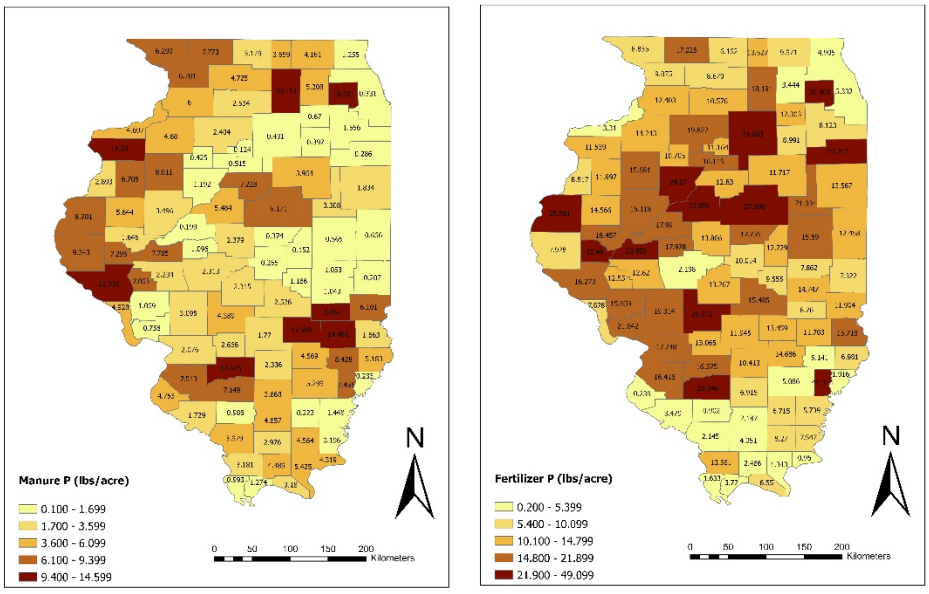
Crop P removal in 2017 at county level ranged from 10.311 to 27.127 lbs/acre (Figure 2A). In general, crop P removal was higher in counties located in Northwest, West, and Central of Illinois than those in other areas, especially in Southwest and Southeast. We assumed that P fertilization in Illinois was related to the yield and maintenance phase of P management, but soil test P data are required to better make sense of P fertilization decisions by growers in Illinois.

County-level P balances

The results showed that P balances of Illinois at county-level ranged from -16.188 to 38.322 lbs/acre/yr (Figure 2B). Overall, Illinois had a negative P balance at -3.312 lbs/acre/yr. About 76% of counties had a negative P balance, ranging from −0.443 to −16.188 lbs/acre/yr, demonstrating P outputs exceeded P inputs. This could reflect on increased crop yields over time. Further, greater P removal than expected suggests a modification in P fertilization may be required in certain areas to maintain agronomic productivity.

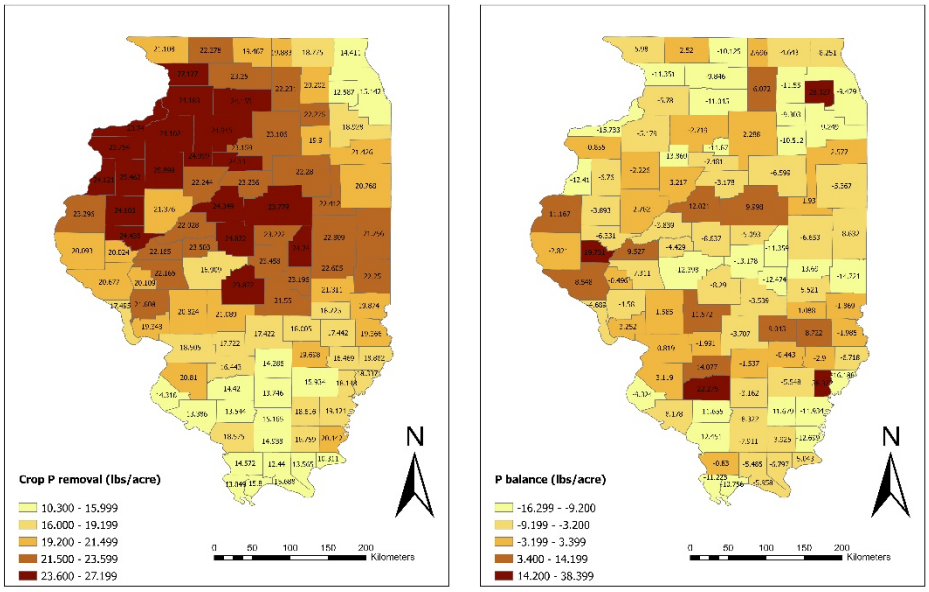
CONCLUSIONS

In 2017, P balances at county-level ranged from -16.188 to 38.322 lbs/acre/yr in Illinois. About 76% of counties had a negative P balance, ranging from −0.443 to −16.188 lbs/acre/yr, indicating less fertilizer compared to the crop P removals was used or higher crop yields are removing more P than expected. Future research should focus on assessing P balances over several years and link those to legacy P to improve sustainable P management practices.



(A) (B)

Figure 1: Total county-level P applied from manure (A) and fertilizer (B) based on USDA-NASS 2017 Census data for Illinois.



(A) (B)

Figure 2: County-level crop P removal (A) and P balance (B) based on USDA-NASS 2017 Census data for Illinois.

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