A REVIEW:

YIELD RESPONSE TO NITROGEN AND PHOSPHORUS OF MAIZE AND SOYBEAN IN ARGENTINE PAMPAS

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INTRODUCTION

Yield response to fertilization depends on multiple factors including both, crop and soil characteristics. General patterns of fertilizer response are difficult to derive from single experiments. In this sense, systematic review and meta-analysis of large datasets are useful for studying and summarizing these patterns.

METHODOLOGY

Data from 498 and 258 fertilization experiments evaluating N and P response in maize (*Zea mays* L.), and from 436 experiments P response in soybean [*Glycine max* (L.) Merr.] were gathered. Most of the experiments came from the so-called "grey literature", i.e. (non-published on peer-review journals). In many cases, researchers who conducted these experiments were asked to meet the minimum data requirements. Most sources of data were:

- Internal reports of INTA (National Institute of Agriculture Technology), CREA (Regional Consortium of Agriculture Experiments), and FERTILIZAR Civil Association.
- Agronomy magazines (without peer-review process)
- Proceedings of Congresses and /or Symposia.
- Peer-review journals (Agron J, SSSAJ, Argentina Soil Science Journal)
- Undergraduate and graduate thesis
- Relevant non-published experiments from public and private sector.

Experiments included in the database meet the following criteria:

- Treatments include at least: a check (non-fertilized) and a fertilized treatment.
- A minimum of 2 replicates per treatment.
- Details of fertilizer management (rate, source, moment, and place)
- A soil-test value (STV): pre-plant N-NO_3^- and Bray-1 P for nitrogen and phosphorus fertilization experiments, respectively.

Additional data included: soil characteristics (soil type, soil carbon, pH, soil texture), rainfall (quantity and distribution), crop management (genotype, crop density, planting date) and statistical design.

DATA MANAGEMENT & ANALYSIS

Databases were built-up and managed with Microsoft® Excel due to its flexibility to import and export data. Data was analyzed by using descriptive statistics and regression analysis. Critical soil test values (CSTV) were estimated by a modification of the Arcsine Logarithm Calibration Curve approach (Dyson & Conyers, 2013).

PRELIMINARY RESULTS

- Experiments cover a wide area of Argentina (from 26° 18' to 38° 33' S and 57° 32' to 65° 25' W), including different soil types (Vertisolls, Argiudolls, Argiustolls, Hapludolls, Haplustolls and Entisolls), and weather conditions (from >900 mm y^{-1} to <600 mm y^{-1}).

NITROGEN

- Despite the wide covered range of rainfall, soil, and crop management conditions, pre-plant nitrate-N test –PPNT- (Ns, 0-60cm) plus N fertilizer (N_f) explained 34% of maize yield variation (**Fig. 1A**).
- Yield response to N varied from -1349 to +10110 kg ha^{-1}, representing relative responses of -11.8% and +189 %. In terms of efficiency, the N agronomic efficiency (NAE) ranged from -33 to 110 kg grain per kg of N fertilizer; and increases of available N (PPNT + N fertilizer) exponentially decreased its partial productivity (15 to 754 kg grain per kg of available N) (**Fig. 1B, 1C**).

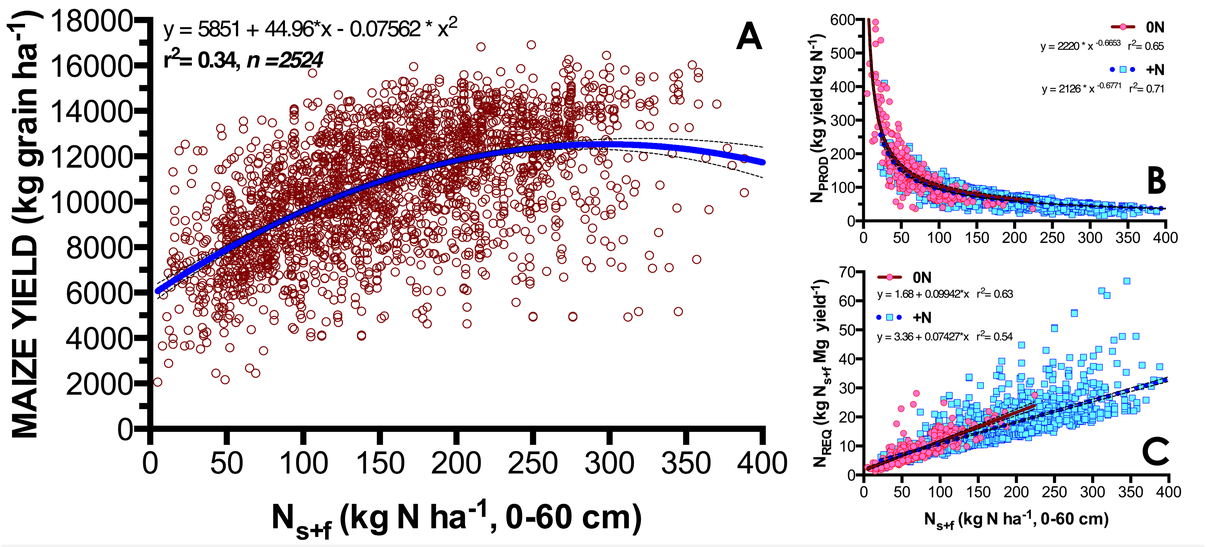

Figure 1. Relationship of maize yield (kg grain ha^{-1}) (A), N productivity (kg yield kg N_{s+f}^{-1}) (B) and apparent N requirement (kg N_{s+f} Mg $yield^{-1}$) (C) with available N at planting (N_{s+f}, kg N-NO_3^- plus N fertilizer) for unfertilized (0N) and fertilized treatments (+N). Data from 498 experiments of N fertilization in maize.

PHOSPHORUS

- Relative yield (% of maximum yield in each experiment) was associated with Bray-1 P level in both crops. Estimated CSTVs show:

i) not consistent differences between soil types for soybean (**Fig. 2**) with a general CSTV = 9.9 mg kg^{-1}.
ii) differences between soil types for maize with higher CSTV for coarser textures (**Fig. 2**).
iii) not consistent differences of CSTVs between maize and soybean, except in coarse textures for maize with higher CTSV.

- Maize yield response to P ranged from -990 to +6722 kg ha^{-1}, with PAEs ranging from -49 to +195 kg maize kg P^{-1}.
- Soybean yield response to P ranged from -1636 to +3233 kg ha^{-1}. with PAEs ranging from -182 to +234 kg soybean kg P^{-1}.
- Soil test value of P explained most of variation of yield response and PAE for both, maize and soybean (**Fig. 3, Fig. 4**).
- P fertilizer rate did not explain the variation of PAE in maize, but explained the variation of PAE in soybean showing different distributions for the different P rate groups (**Fig. 3**).
- Considering 3 different classes of Bray-1 P level (low, medium and high), in both crops, STV lower than 10 mg kg^{-1} showed the highest probability to obtain PAE superior than historical prices ratios.

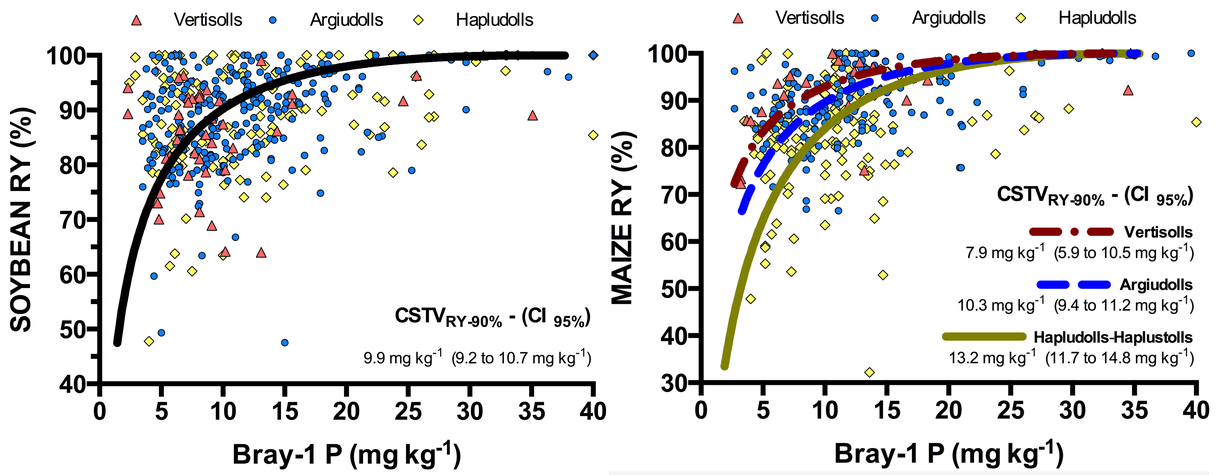

Figure 2. Relationship between relative yield (RY, %) and soil Bray-1 P level in the top-soil (0-20 cm) for soybean (left) and maize (right). A single function was fit for all soil types in soybean (r = 0.36). Different functions for each soil type in maize (r = 0.61 for Vertisolls, r = 0.51 for Argiudolls, r = 0.25 for Hapludolls-Haplustolls). Data from 436 and 258 experiments of P fertilization in soybean and maize, respectively.

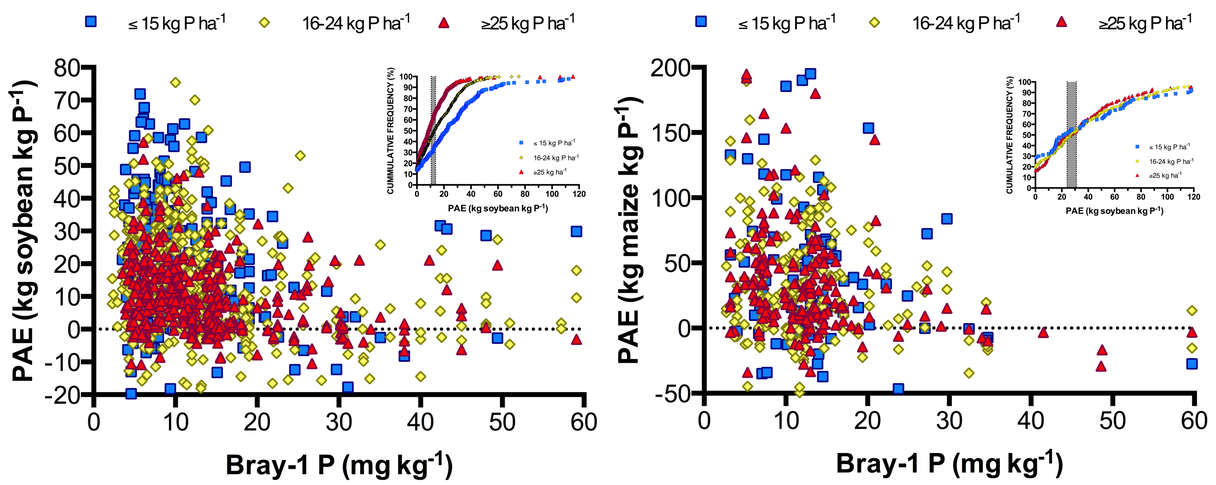

Figure 3. Relationship between P agronomic efficiency (PAE, kg grain kg applied P^{-1}) and soil Bray-1 P level in the top-soil (0-20 cm) for soybean (left) and maize (right) with 3 different levels of P rate and the normal cumulative distribution. Grey strips represent percentiles 25% and 75% of historical prices ratio (kg grain kg P^{-1}) in Argentina. Data from 436 and 258 experiments of soybean and maize, respectively.

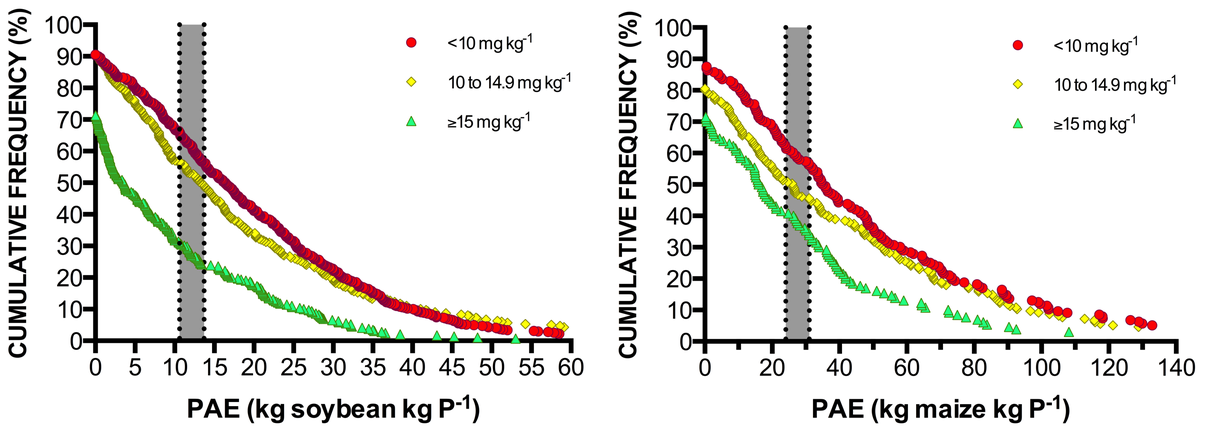

Figure 4. Relative frequency of PAE (RY, %) for different levels of Bray-1 P in the top-soil (0-20 cm) for soybean (left) and maize (right). Grey strips represent percentiles 25% and 75% of historical prices ratio (kg grain kg P^{-1}) in Argentina. Data from 436 and 258 experiments of soybean and maize, respectively.

PRELIMINARY CONCLUSIONS AND PERSPECTIVES

- Maize yield showed a consistent relationship with the N availability at planting, despite the wide range of conditions of the experiments. In the same way, N productivity (N_{s+f} at planting) showed a strong negative trend. The next step will be making groups and a comparison analysis between them.
- Yield response to P and PAE showed a consistent relationship with Bray-1 P level. Differences in CSTV between soil types for maize require further analysis to give more details about this behavior.
- Since the database is currently under build-up process, the analysis of within and between experiments variability (meta-analysis) have not been performed yet, a next phase of this project.

ACKNOWLEDGEMENTS

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