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## An open database of crop yield response to fertilizer application for Senegal

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### **Abstract.**

*Food security is one of the significant global challenges of our time. Nearly 16% of the current food security literature focuses on global food security, and approximately 35% focuses on Africa. Many studies have been conducted to mitigate food security deficits, focusing on the evaluation of crop management practices to increase productivity, including nutrient fertilization. The development of decision support tools for large-scale systems requires access to information, and one way to achieve this is through the systematic collection of data published in the scientific literature. The objective of this study was to create an open database by integrating the available information on the production of the main crops of a region and the addition of nutrients, using Senegal as a case study. A literature search was conducted in Scopus, Web of Science, Science Direct, and Google Scholar. The database contained 98 published articles, 505 experiments, and 3,131 observations. The most studied crop was rice, while the most studied nutrients were phosphorus and potassium. This research is a first step to promote the use of open databases to support decision-making tools and to shed light on the current status of fertilizer evaluations in Senegal.*

### **Keywords.**

*Africa, Fertilization, Nitrogen, Phosphorus, Potassium*

## Introduction

Food security is one of the significant global challenges of our time. Nearly 16% of the current food security literature focuses on global food security, and approximately 35% focuses on Africa (Cooper et al., 2020). While regions such as East Africa and West Africa have recently received a large amount of food security research, there are notable disparities between the proportion of research received by the different countries that comprise these regions (Cooper et al., 2020).

Many studies have been conducted to mitigate food security deficiencies, focusing on evaluating crop management practices to increase productivity, including nutrient fertilization (Nyagumbo et al., 2020; Zingore et al., 2022; Aramburu Merlos et al., 2024). In some regional studies, the approach used to generate information was experimental (Zingore et al., 2022), while in others it was based on farmer surveys (Aramburu Merlos et al., 2024) or the use of models (e.g., QUEFTS, crop simulation models) (Fosu-Mensah et al. 2012, Magaia et al. 2017, Rurinda et al. 2020).

Therefore, developing decision support tools for large-scale systems requires access to information, which can be acquired through the generation of new data or gathering existing data. The latter implies the integration of different sources of information, their homogenization, and their subsequent analysis to determine their utility and spatial scope.

The objective of this study was to create an open database by integrating the available information on the production of the main crops of a region and the addition of nutrients, using Senegal as a case study.

## Materials and methods

A literature search was conducted in Scopus, Web of Science, Science Direct, and Google Scholar in November 2023, according to the PRISMA guidelines (Page et al., 2021). The search equation used in titles, abstracts, and keywords was: Senegal AND (Nutrient OR Fertilization OR Fertilizer OR Rates OR Doses OR Nitrogen OR Phosphorus OR Potassium OR Sulfur OR Sulphur) AND Yield. In Science Direct, the words "rates," "doses," and "sulfur" were removed from the search equation due to the limited number of words allowed in this search engine.

In parallel, a French-language search was performed in Scopus, Web of Science, and Google Scholar, using the search equation: Sénégal AND (Nutriment OR Fertilisation OR Engrais OR Taux OR Doses OR Azote OR Phosphore OR Potassium OR Soufre) AND Rendement.

The total number of scientific articles published in peer-reviewed journals and reports was 5325 articles. After removing duplicates, the number of articles remaining was 5026 (Fig. 1). Subsequently, a title and abstract screening was performed to remove articles that were not related to the topics described in the search equation, resulting in a total of 252 articles and reports. Finally, a whole text screening was performed, keeping those articles that present the quantification of the nutrient effect addition (i.e., allowing the contrast between treatments) and had at least two fertilization rates. The final database included 98 published articles, 505 experiments, and 3131 observations (Fig. 1).

Title and abstract screening of English-language articles and reports was carried out using a 'double-blind' method by two groups of two reviewers each. For articles and reports in French, screening was carried out by a single reviewer. Title and abstract screening was carried out using the Revtools package in R statistical software (Westgate 2019, R Core Team 2023). Data were

digitized manually by direct collection or, in the case of graphs, using WebPlotDigitizer (<https://automeris.io/WebPlotDigitizer>).

The relationships between variables of interest were evaluated through quantile relationships using the quantreg package (Koenker, 2023).

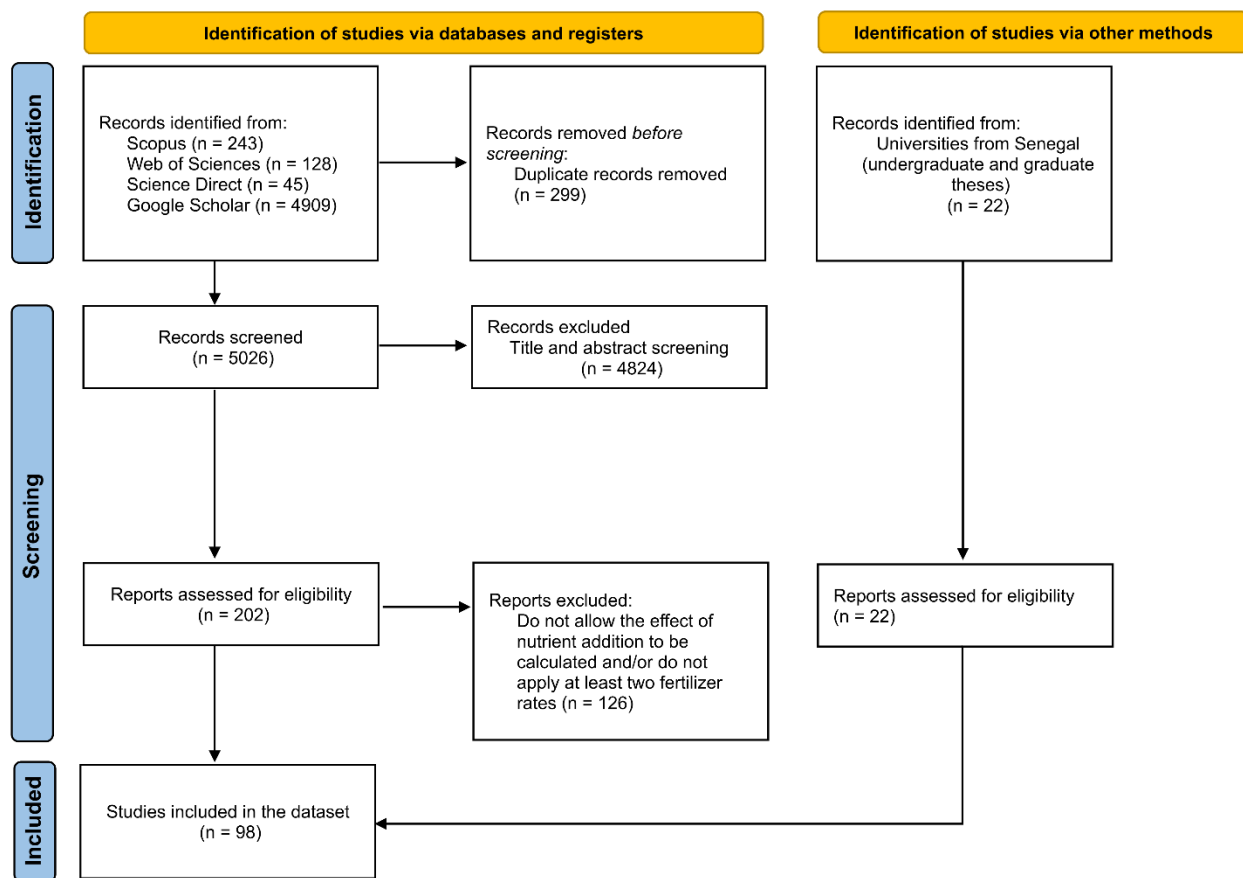
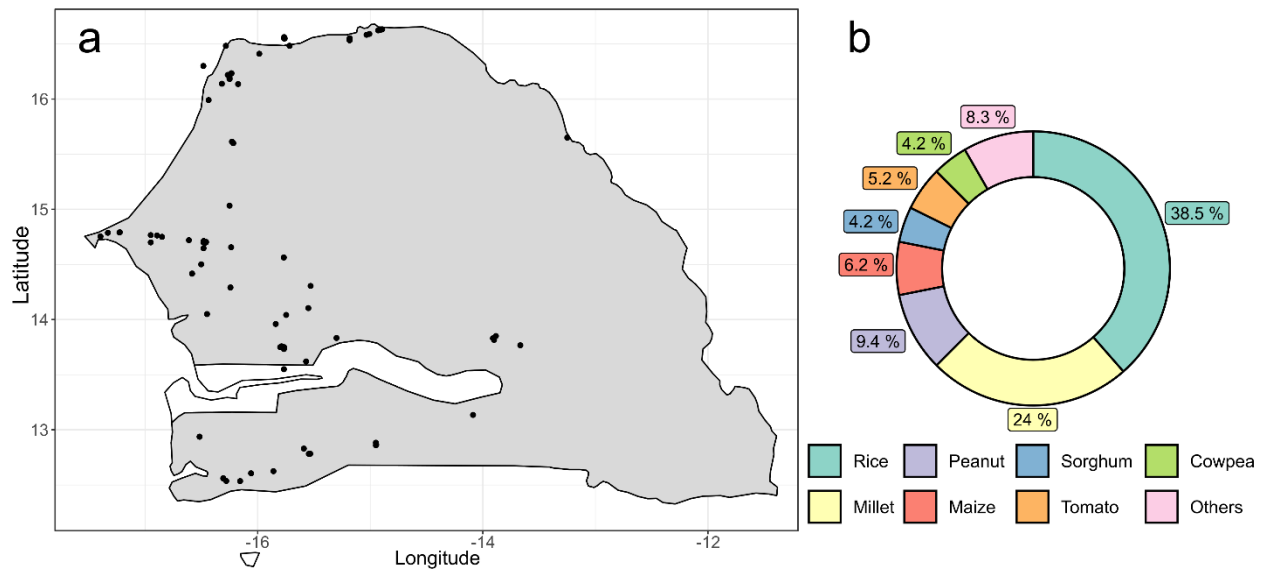


Fig. 1. PRISMA flow diagram. 'n' corresponds to the number of articles in each process step.

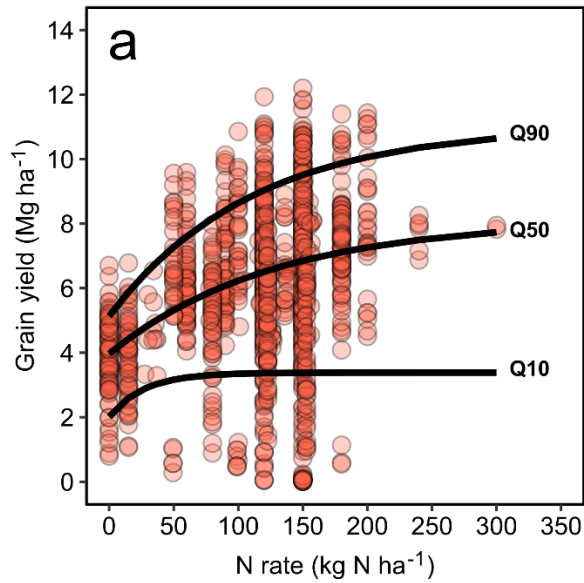
## Results and discussion

Most of the collected data came from experiments conducted in western Senegal (Fig. 2.a). Furthermore, rice, millet, peanut and maize were the most frequent crops in the database, accounting for ~78% of the collected articles (Fig. 2.b).

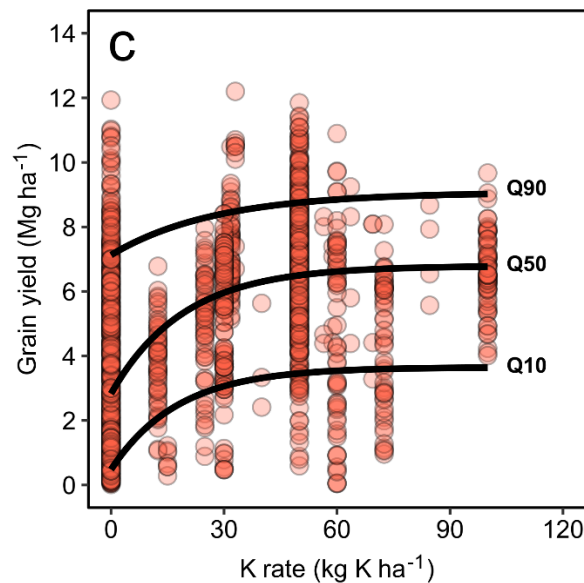
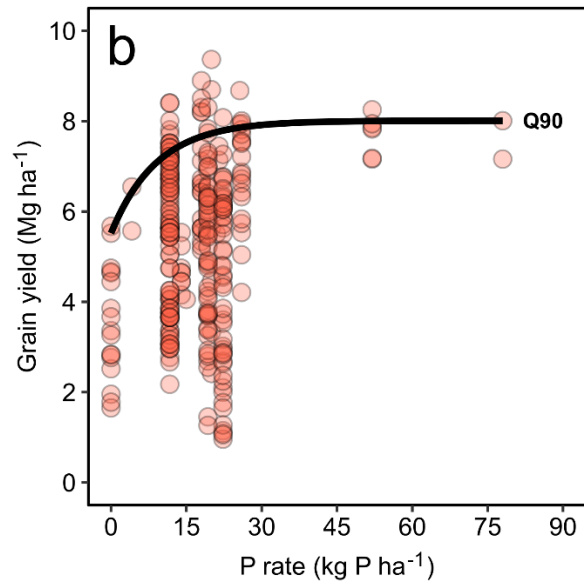


**Fig 2.** a) Distribution of experiments from which data were collected. b) Proportion of articles referring to each crop.

Phosphorus was the least studied nutrient (Fig. 3.b), while more information was available for N and K (Fig. 3.a and 3.b). Regarding the maximum grain yields observed for these nutrients, they were 11, 8, and 9 Mg ha<sup>-1</sup> for N, P, and K, respectively (i.e., parameter 'a' of the exponential equation adjusted to Q90) (Fig. 3). In agreement with Hernandez et al. (2021), the wide range of grain yields observed for the same rate of nutrient application highlights the variability of the climatic and soil conditions collected. It is worth noting the limited information available to assess soil nutrient availability in the database created.



**Fig. 3.** Relationship between grain yield and fertilization rate applied of a) nitrogen, b) phosphorus, and c) potassium for rice. The fitted functions correspond to exponential functions ( $y = a * (1 - e^{(-b * (x + c))})$ ) for quantiles 10, 50 and 90 (Q10, Q50 and Q90, respectively).



## Conclusions

This research marks the initial stage in encouraging the use of open databases to support decision-making tools. The results shed light on the current status of fertilizer evaluations in Senegal, suggesting the need for more focus on the central region of the country and to study the impact of nutrient addition with appropriate experimental designs. The involvement of on-site reviewers (French speakers) facilitated the inclusion of grey literature (such as reports and dissertations), which is a relevant source in data-poor environments.

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