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SolACE - Solutions for improving Agroecosystem and Crop Efficiency for water and nutrient use

Deliverable D1.3
Analysis of past research data

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1. Introduction

The present report is part of WP1's task 1.3 - *Use of models to extrapolate and integrate data to explore future scenarios and complement field experiments* - and represents a sprint data analysis based on a first search of data from existing European Union (EU) projects on yield response to N, P and water stresses (or a combination of any of these factors), both at field and experimental level and for the three crops under analysis in the project: bread wheat, durum wheat and potato.

The work described and presented here comprises two distinct stages: a) the collection of data concerning the grain yield response of wheat to different nitrogen fertilization rates and b) the analysis of these data. The first task includes the collection of available data from literature i.e. articles describing wheat field trials where nitrogen fertilization was tested among other variables. The analysis included the collateral effects of climate, soil type and field trial year of installation. Due to the limited amount of studies targeting potato and phosphorus fertilization, this work is focused on wheat and nitrogen responses.

The difficulty in obtaining viable data for the present analysis (many studies with data in graphic form, average values or tables with summary results) motivated a delay in the submission of the present delivery. This delay impacts Task 1.3 in which these results are to be used as a starting point for modelling the soil-plant-atmosphere-crop management response in experimentally untested conditions. However, this is considered not critical because the establishment of the models for each sub-system needs to be tackled first and this can be done with the use of alternative input data.

2. Materials and Methods

The present report uses data collected and described in several articles concerning grain yield response to nitrogen fertilization rates. The articles used in this analysis can be found in Table 1.

Table 1- Code and title of the different studies analized and the treatments used in the field trials.

Code REF	Title*	Tested treatments
1	*Identification of traits to improve the nitrogen-use efficiency of wheat genotypes*	Different N fertilization rates on different years and different locations and different genotypes (average)
2	*Genetic variability in biomass allocation to roots in wheat is mainly related to crop tillering dynamics and nitrogen status*	Different N fertilization rates and different genotypes
3	*Efficiency of nitrogen in wheat under Mediterranean conditions: effect of tillage, crop rotation and N fertilization*	Different N fertilization rates on different years
4	*The Efficiency of Nitrogen Fertilization of Spring Wheat Depending on Seasonal Rainfall*	Different N fertilization rates with or without catch crops
5	*Nitrogen fertilization and foliar urea effects on durum wheat yield and quality and on residual soil nitrate in irrigated Mediterranean conditions*	Different N fertilization rates and fertilization timings on different years
6	*Strategies to Improve Nitrogen Use Efficiency in Winter Cereal Crops under Rainfed Conditions*	Different N fertilization rates on different years
7	*On the relationship between N management and grain protein content in six durum wheat cultivars in Mediterranean environment*	Different N fertilization rates and fertilization timings on different years (average)

8	*Long-term wheat response to nitrogen in a rainfed Mediterranean environment: Field data and simulation analysis*	Different N fertilization rates on different years
9	*Breeding progress in morpho-physiological, agronomical and qualitative traits of durum wheat cultivars released in Italy during the 20th century*	Different N fertilization rates and fertilization timings on different genotypes
10	*Genetic improvement effects on yield stability in durum wheat genotypes grown in Italy*	Different N fertilization rates and fertilization timings on different genotypes

**The full reference is provided in the References section with the same Reerencef Code.*

The information available for the field trials under analysis in each study was collected and the location was plotted in a pedoclimatic map of European regions. Therefore, for each trial, the climatic region and soil type was determined. Figure 1.

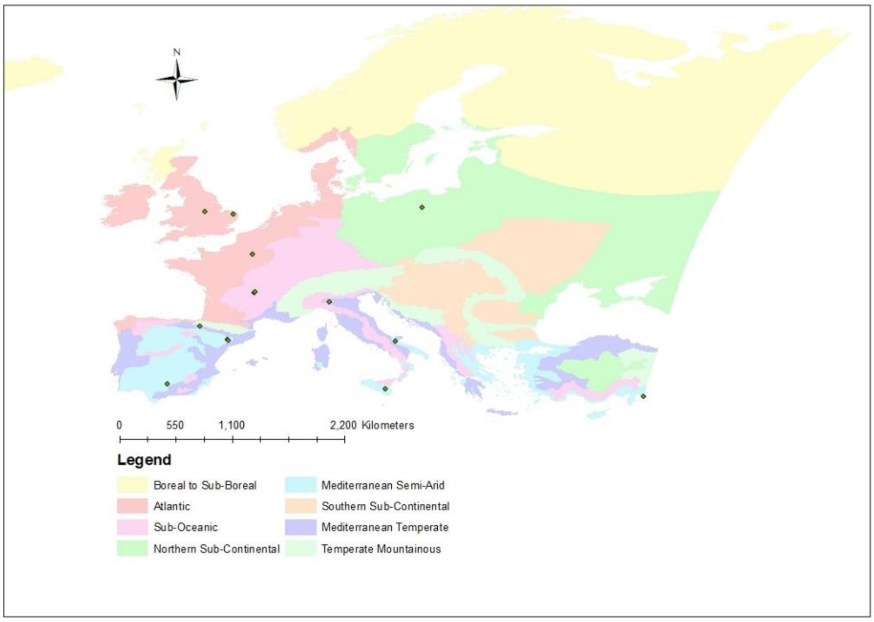

Figure 1 - Location of the different field trials analysed in this study

3. Results

3.1 Grain Yield response to Nitrogen fertilization rates in wheat

A total of 10 studies were analysed and data from nitrogen fertilization effect on grain yield was collected for wheat. These data referred to 5 different climatic regions in Europe (Atlantic, Sub-oceanic, Mediterranean Semi-Arid, Temperate Mediterranean and Northern Sub-continental), 3 different soil types (Cambisol, Luvisol and Vertisol) and covered years from 1995 to 2008.

The analysis included 189 pairs of grain yield/N fertilization. The minimum and maximum values obtained for grain yield in this analysis were 1.10 and 9.65 ton ha^{-1} and the nitrogen fertilization rate applied varied between 0 and 240 kg N ha^{-1}. Results show that there is a general tendency of increased grain yield with increasing nitrogen fertilization rate. However, R^2 is low (0.247) showing that many other factors are influencing this result.

3.2 Grain Yield response from different years, climatic regions and soil types

Results were also analysed by separating grain yield response to nitrogen fertilization rates taking into account the field trial year, the soil type and the climatic region.

Results are available for years ranging from 1992 to 2008. The grain yield response to N increase in the fertilization rate was higher in 2001 (R^2=0.87) followed by 2008 (R^2 = 0.63) and 2004 (R^2=0.5359). The first years analysed show, on the contrary, very little correspondence between grain yield achieved and the nitrogen fertilization rates.

Results show that in general nitrogen fertilization rates have a positive impact on grain yield within each climatic region. The exception was observed in the Sub-oceanic region where higher nitrogen doses did not result in grain yield increase. For the regions of Northern Sub-Continental, Temperate Mediterranean and Mediterranean Semi-arid the response was higher while in the Atlantic the increment in grain yield was lower.

The results show that only three different soil types were present in the field trials analysed in this study. However, soils such as Cambisol and Luvisol are among the most common soils in Europe, especially when considering agricultural areas. The R^2 values registered (varying between 0.23 and 0.53), show that generally there is an influence of the soil type on grain yield response concerning the different N doses applied but that correspondence is not very strong. The highest correlation was found in Vertisols, although the range of nitrogen fertilization rates analysed here was narrower.

4. Conclusions

Although it was possible to analyse 189 pairs of data concerning grain yield response to different N fertilization rates specifically in wheat, the interpretation of results remains difficult because not enough representative data is available to understand the trends observed in the different years, climatic regions and soil types.

The correlation between grain yield and nitrogen fertilization rates was positive with an R^2 of 0.247. Also, in the years of 1995 and 1996 an increase in nitrogen fertilization did not necessary result in higher yields, while in 2001, 2004 and 2008 there was a clear response of the grain to the nitrogen input. This possibly highlights the influence of rain and temperature, which was variable during these periods. Situations where wheat growth was limited by any abiotic factor did not benefit from an extra nitrogen fertilization input. Further analysis should take into account the average annual rain and temperature registered during these periods to understand these limitations. This is also the case for the influence of the different climatic regions on the grain yield response to nitrogen fertilization. Results show that for the regions of Mediterranean Semi-Arid and Northern Sub-Continental the wheat grain yield responded linearly to the nitrogen fertilization rate, but it should be taken into account that this analysis did not include a significant amount of data from different years, where necessarily the rain and temperature were variable. Finally, we observed also a correlation between the soil type and the grain response to different N doses. This should also be extended to obtain more data where other soil types where present. The response should be correlated to different soil characteristics that might be involved in the biological and non-biological processes of the nitrogen cycle occurring in the soil that ultimately impact the nitrogen uptake by wheat.

Future work includes therefore: 1) the collection of more data from N fertilization rates and the corresponding effects on grain yield; 2) the additional collection of meteorological and topographical data as well as on different management systems used, fertilization timings and soil characteristics and 3) a meta-analysis including all these factors to understand which limitations affect the grain response to nitrogen fertilization.

5. Partners involved in the work

The University of Évora (UE), partner number 10 and the James Hutton Institute (JHI), partner number 5.

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