

Soybean Yield Gaps in Brazil: Climate x Crop Management Causes

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Introduction

Brazil is one the most important soybean producers in the world, representing a very important crop for the country, considering that it is used for several purposes, from food to biodiesel production. The levels of soybean yield in the different growing regions of the country vary considerably, which result in yield gaps of considerable magnitude. Therefore, the aim of this study was to propose a procedure to estimate de yield gap for soybean crop in Brazil, based on the use of a simple crop simulation model, in order to identify the gaps magnitudes and causes for different production regions in the country.

Material and Methods

The yield gap was determinate by the difference between attainable and actual yields (Figure 1), which was used to demonstrate how much of the yield gap comes from the crop management, and also between potential and attainable yields to understand how much comes from water deficit.

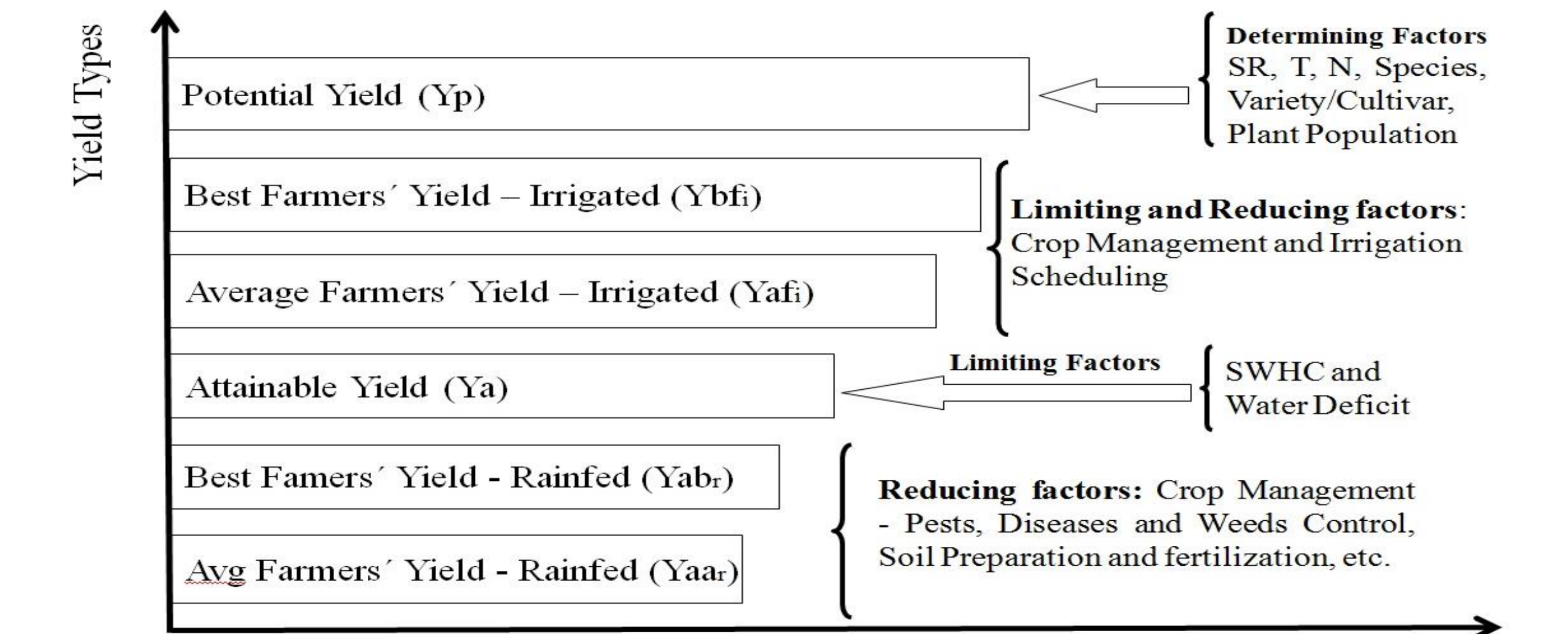


Figure 1. Types of yield and their factors. Adapted from Rabbing (1993); van Ittersum and Rabbinge (1997); Lobell et al. (2009); Hall et al. (2013); van Ittersum et al. (2013).

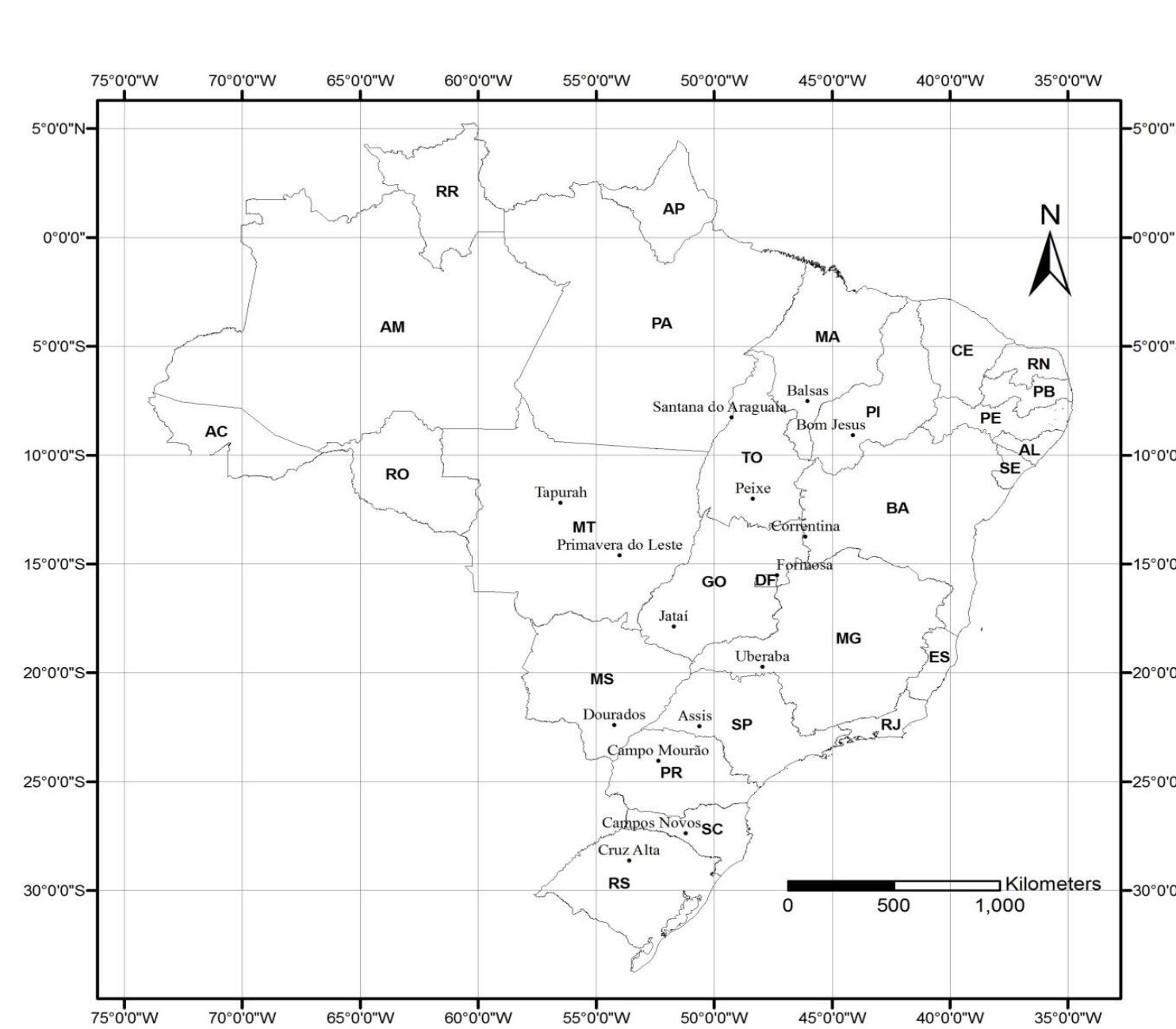


Figure 2. Brazilian locations used in the present study for soybean yield gap estimates.

Soybean potential yield (Y_p) was estimated by the FAO Agro-Ecological Zone Model and the attainable yield (Y_a) was estimated by penalizing Y_p by the water deficit along the different crop phases, considering the water response factor (K_y). Actual soybean yield (Y_a) data were obtained from the official surveys of the Brazilian Institute of Statistics and Geography (IBGE) for the period of 1980 to 2011. Y_p and Y_a were simulated for the soybean sowing window of each of the following production regions across the country, from the south to the north (Figure 2).

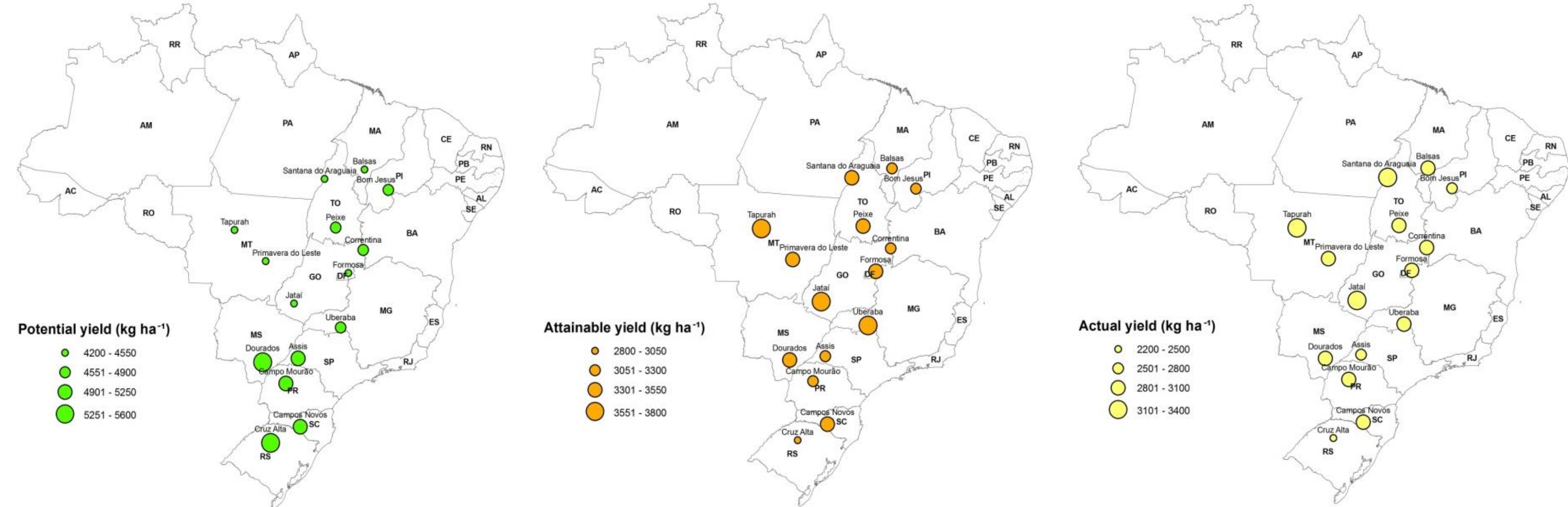


Figure 3. Potential, attainable and actual soybean yields for the main producing regions in Brazil.

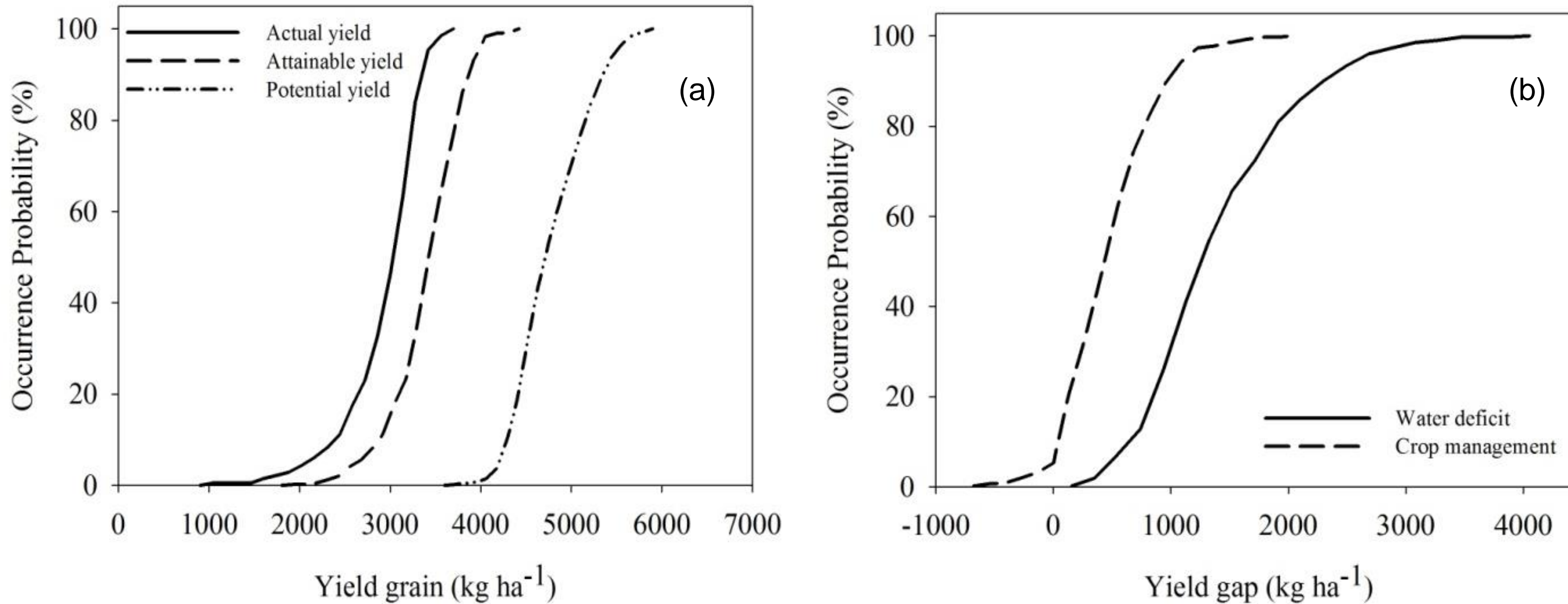


Figure 4. Probability of occurrence of soybean actual, attainable and potential yields (a) and for yield gap (b), in the fifteen studied locations in Brazil.

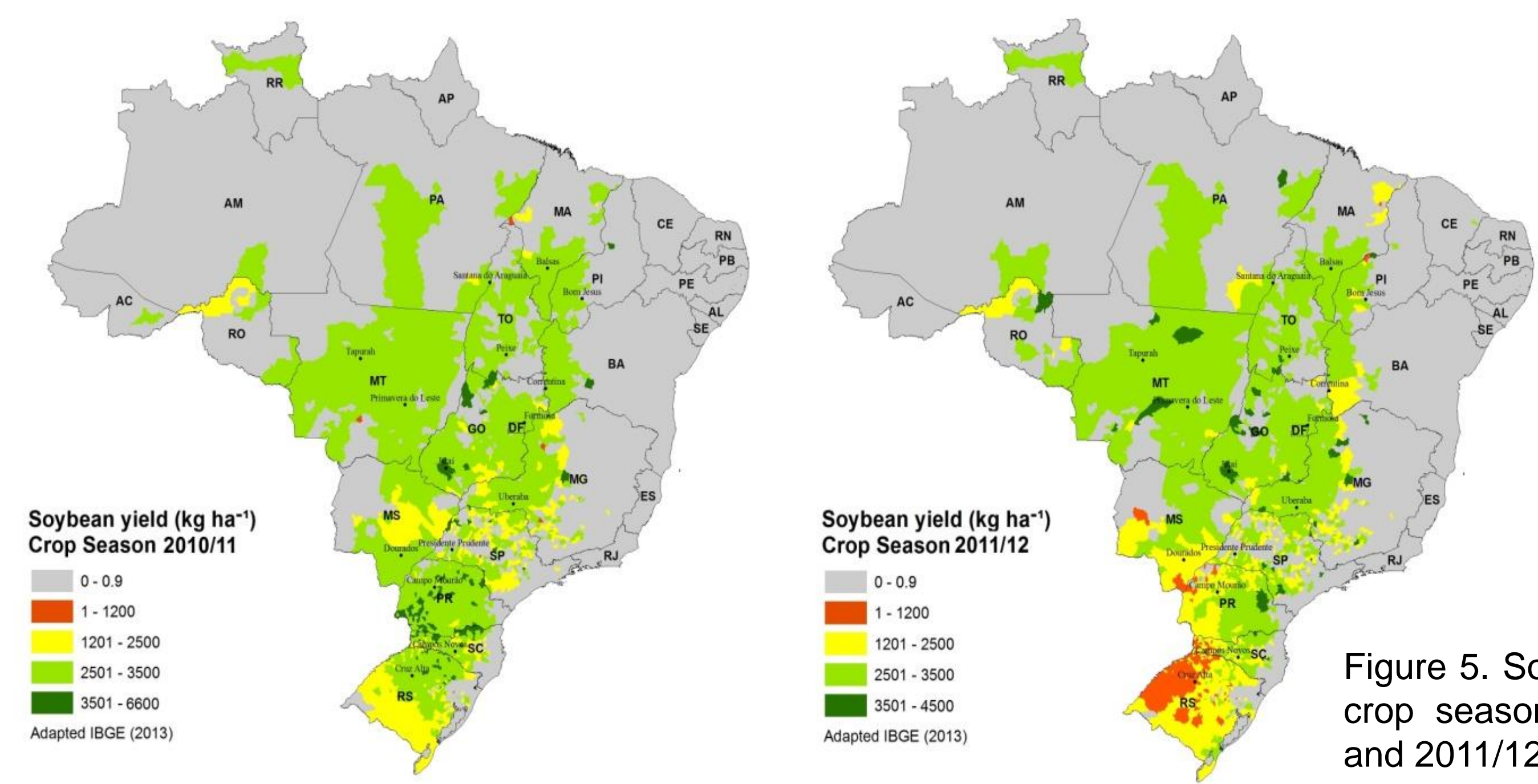


Figure 5. Soybean yield in the crop seasons of 2010/11 (a) and 2011/12 (b), in Brazil.

Results

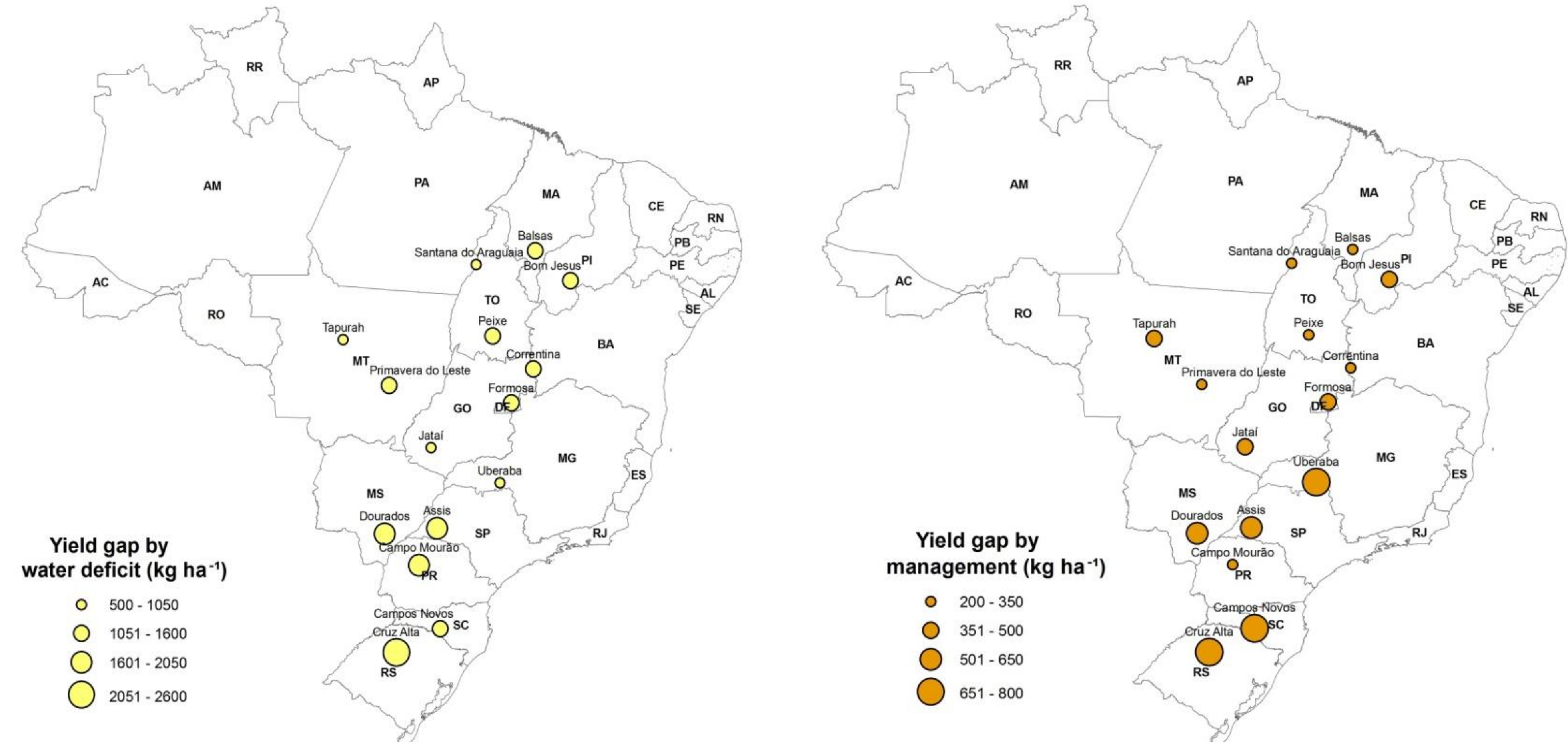


Figure 6. Soybean yield gap caused by water deficit and management in the main producing regions of Brazil.

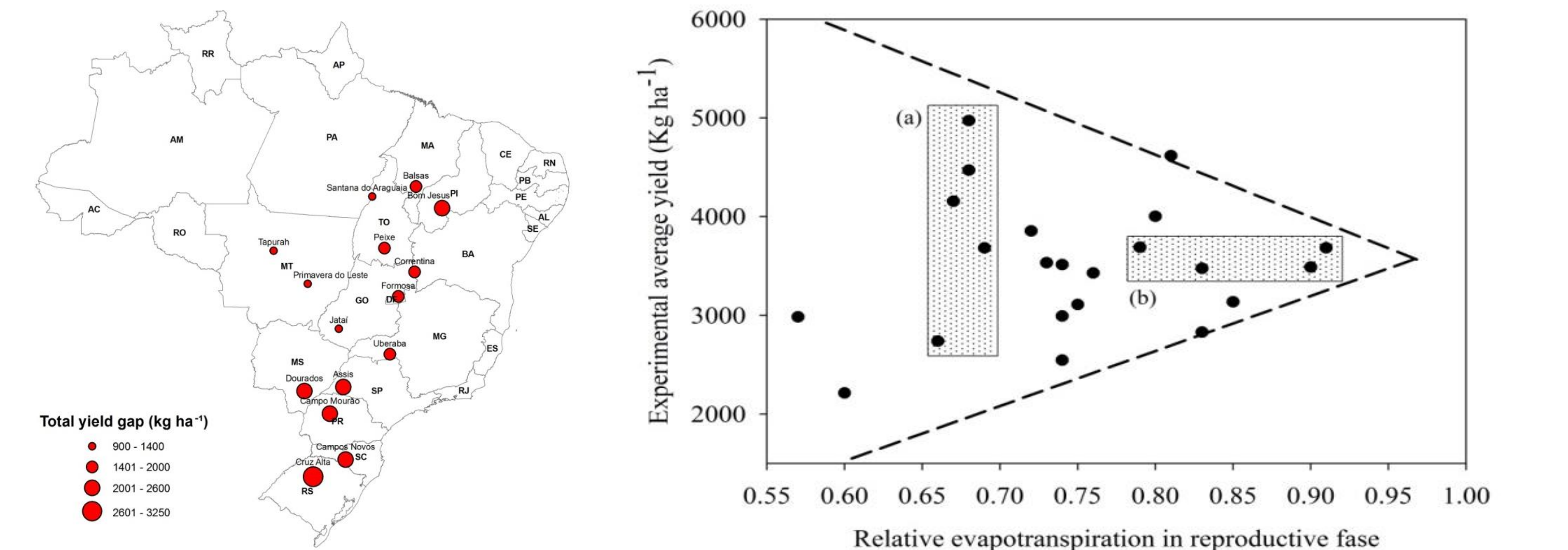


Figure 7. Soybean total yield gap caused by water deficit and management in the main producing regions of Brazil.

Figure 8. Relationship between relative evapotranspiration in the soybean reproductive phase and experimental average yields for 23 sites in southern Brazil

The maximum yield gaps observed were **2048** and **4053 kg ha⁻¹**, respectively, for crop management and water deficit. In relative terms, the soybean yield gaps were, in average, of **28.8** and **13.6%**, respectively, **by water deficit and crop management**. The main factor that reduced soybean yield in Brazil was the **climatic stresses** caused by **water deficit** along the crop cycle. About the crop management, the main causes of yield gap are **soil physics and fertility**, **pest** (like *Helicoverpa spp.*), **diseases** (like *Phakopsora pachyrhizi*) and **weeds** (like *Conyza bonariensis*).