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Spatiotemporal dynamics of soybean crop in the Matopiba region, Brazil (1990–2015)

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ABSTRACT

Brazil is a world leader in the production and export of grains, particularly soybeans. The newest agricultural frontier in Brazil is the Matopiba region, which is a continuous zone formed by the states of Maranhão, Tocantins, Piauí, and Bahia, located mostly within the Cerrado biome. The objective of this study was to analyze the spatiotemporal dynamics of soybean production and yield in the Matopiba region. We analyzed municipality-based planted areas and production data obtained by the Brazilian Institute of Geography and Statistics during 1990–2015. Yield was estimated from the production and planted area, and the data were analyzed using global and local Moran indices. The results showed that soybean production in the Matopiba region does not occur randomly. Positive and significant autocorrelation was found at the beginning of the time series among those municipalities located in the west of Bahia. This region influenced the soybean expansion from south to north. Currently, high-production areas are concentrated in two autocorrelated blocks: one in western Bahia and the other in the central Matopiba region. Analysis of spatial autocorrelation involving yield showed a decreasing trend at the end of the time series. The presence of municipalities with high yield surrounded by others with low yield, and vice-versa, were observed. The findings of this study could assist local and regional agricultural planning in the Matopiba region, and support related analyses in other fields of agriculture, the environment, and logistics.

1. Introduction

Because of its considerable territorial extent and its favorable climate, topography, and soil physical properties that support extensive rainfed crop production, Brazil has become one of the main exporters of agricultural commodities, such as soybean, corn, coffee, sugarcane, and cotton (MAPA, 2016a; Mueller and Mueller, 2016). In 2015, the annual crops that presented the largest planted areas in Brazil were soybeans (32 million ha), maize (16 million ha), and sugarcane (10 million ha) (IBGE, 2015). Currently, Brazil and the United States are the leading producers of soybeans (MAPA, 2015). In 2015, Brazil exported approximately 57 million tons of soybeans (An and Ouyang, 2016), primarily to China (Lima et al., 2017). In 2016/2017, Brazil produced 114 million tons of soybeans (USDA, 2017). Analysis by the United Nations Food and Agriculture Organization has indicated that soybean production in Brazil will increase by 37% over the next 10 years (OCDE/FAO, 2015).

Soybean planting began in Brazil in the 1940s as an option for crop rotation with wheat (Brown et al., 2005), and the crop adapted well in the southernmost part of the country because of the temperate climate. According to Paludzyszyn Filho et al. (1993), soybean became important in Rio Grande do Sul State because of the exportation. Gradually, because of investments by the Brazilian government in research institutions, soybean plants were genetically modified to improve adaptation in other regions of the country with tropical climate (Guimarães and Leme, 1997; Andersen et al., 2002). In addition, the use of chemical fertilizers was implemented to correct the predominantly acidic soils with low natural fertility found mainly in central parts of the country (Delgado, 1985). Brazilian Agricultural Research Institute (Embrapa Cerrados), created in 1973 by the Ministry of Agriculture, played a key role here since its research allowed remarkable increase in the soybean production in Brazil (Mueller and Mueller, 2016).

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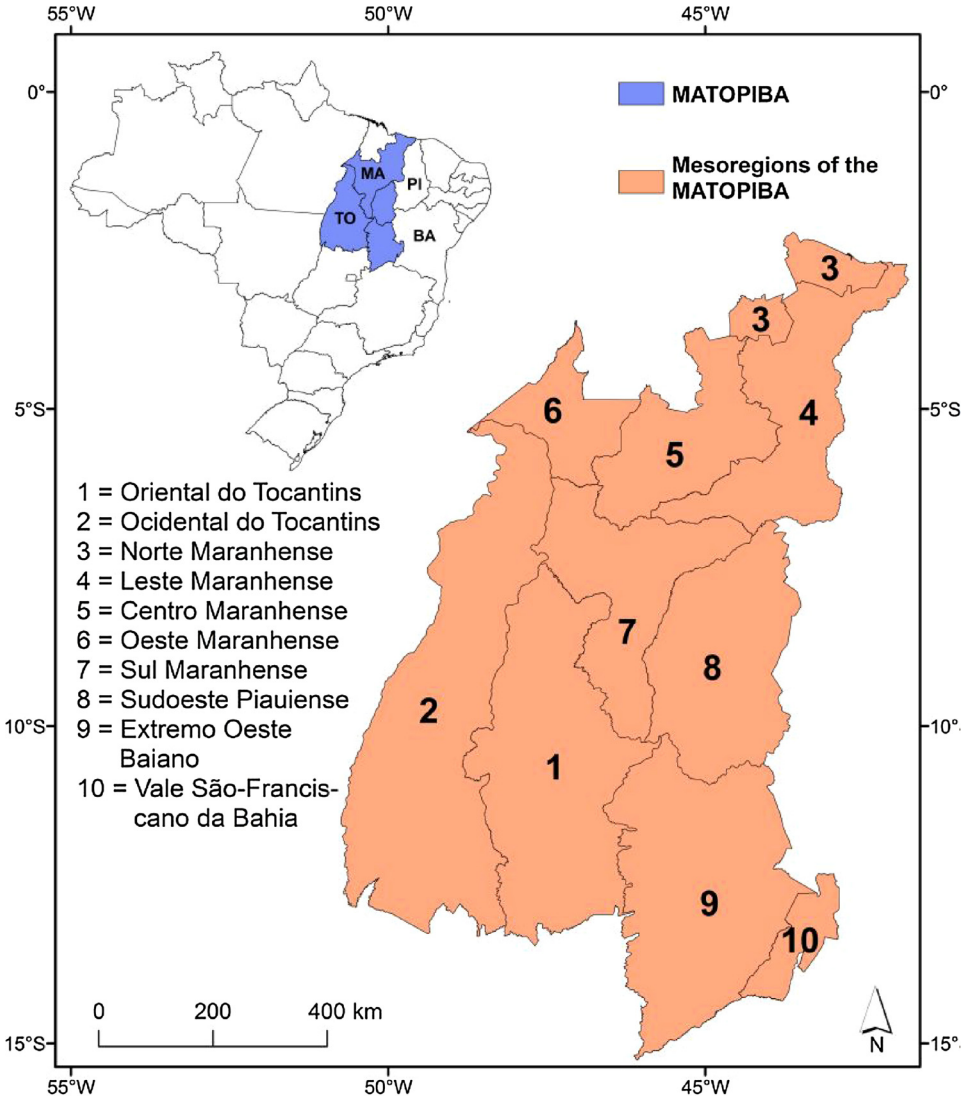

Fig. 1. Map of the Matopiba region in Brazil, subdivided into 10 mesoregions. Each mesoregion corresponds to a subdivision of a Brazilian state that aggregates a varying number of municipalities with high levels of economic and social similarity. State identification: MA = Maranhão, TO = Tocantins, PI = Piauí, and BA = Bahia.

At the same time, because of the approved agrarian reform legislation, large landowners started to prevent against land loss for small farmers, rural workers, and landless peasants by increasing their production and investing in mechanization (Mueller and Mueller, 2016). Other relevant factors that contributed to the expansion of soybean in Central Brazil included the public tax incentives to open new areas for soybean and for establishment of companies for grain storage and processing, the availability of large areas with flat topography (plateaus), that is, favorable for mechanization, the relatively high precipitation conditions for rainfed agriculture, and the relatively good economic and technological levels of the farmers from southern part of the country that migrated to Cerrado (Dall'Agnol (2008); Campos, 2010).

Since 1990, the Brazilian government reduced its direct involvement in agriculture. On the other hand, private sector started to invest strongly in this sector (Alston et al., 2016). The country also implemented a series of more open and predictable political and economic institutional arrangements (Alves and Pastore, 1978). This lower need for direct political intervention in areas such as credit and price management allowed the country to grow even more in the agricultural sector (Mueller, 2009).

New agricultural frontiers were created in the Cerrado biome, e.g., regions of western Bahia State, southeastern Goiás State (municipalities of Jataí and Rio Verde), and the central region of Mato Grosso State (municipalities of Lucas do Rio Verde, Sinop, and Sorriso). Agricultural frontier is defined as a region dominated by natural vegetation that started to face intensive agriculture-related land occupation. The most recent agricultural frontier of the Cerrado is the Matopiba region, a continuous zone formed by the states of Maranhão, Tocantins, Piauí, and Bahia (Miranda et al., 2014). In this region, infrastructure is poor, land prices are cheap, and the climate and topographic relief are favorable for rainfed agriculture. Currently, soybean is the main agricultural crop of Matopiba (MAPA, 2017).

Following the rapid agricultural expansion in Matopiba, the Brazilian government issued Federal Decree No. 8,447 on May 6, 2015, establishing an Agricultural Development Plan for Matopiba. The purpose of this decree was to promote and coordinate public policies for economic and sustainable development of agricultural and livestock activities in the Matopiba region. The plan proposes guidelines for federal programs, projects, and actions to be undertaken with the objectives of improving both the living standards of the local population and the economic growth of the country. For this plan to succeed, it is of great relevance to understand the spatiotemporal dynamics of the crops produced in this region, with emphasis on the spatial clusters that