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Characterization of cotton cultivation: spatio-temporal considerations for Mato Grosso State

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Abstract

The State of Mato Grosso produces approximately 45% of cotton in Brazil, which makes it necessary to characterize the crop in this State. The objective was to analyze cotton production in the State of Mato Grosso through official data from the IBGE's Systematic Survey of Agricultural Production (LSPA), both for micro-regions and meso-regions. Temporal graphs and maps were constructed for planted area, quantity produced and yield. Temperature and precipitation were analyzed for the crop cycle period. Northern Mato Grosso has the largest area and quantity of seed cotton production. It is also the mesoregion with the highest growth between 2005 and 2016. However, fluctuations in planted area were reported due to supply and demand issues. The Parecis micro-region is highlighted as the one with the highest production, area and productivity. In addition, climatic factors suggest that most micro-regions are ideal for cotton production. In conclusion, production and productivity in Mato Grosso State can continue to increase with a stable market and the introduction of technology.

Keywords

Gossypium hirsutum; Agricultural production.; Time series

Introduction

Cotton (*Gossypium hirsutum* L.) is produced by about 60 countries and ranks as one of the most important fiber crops in the world. The global area dedicated to this crop is 35 million hectares, generating around US$12 billion per year. In recent years, Brazil has remained among the five largest world producers, along with India, China, the United States and Pakistan (ABRAPA, 2020).

Cotton production in Brazil is mainly concentrated in Mato Grosso, with 85% of the country's total cotton area (ABRAPA, 2020). It is expected that cotton production in Mato Grosso continues growing since, in the last 10 years, the planted area has increased by 32% (CONAB, 2021). This increase is based on a recovery of domestic prices, higher margins versus other commodities (corn, soybean), and a recovery of the domestic economy (Barros et al., 2022). Therefore, it is urgent to know how this crop has evolved over the years in Mato Grosso.

In Brazil, the Brazilian Institute of Geography and Statistics (IBGE) is responsible for keeping the crop statistics, publishing the monthly systematic survey of agricultural production (LSPA). However, there is little compiled information, especially statistics about the dynamics of important crops such as cotton. This information is an important tool, mainly for improving agronomic practices and breeding new cultivars (Junges et al., 2012). In addition, crop statistics are used in the political sphere to make decisions on the composition of prices that have repercussions on the economy and society (Cao et al., 2020).

In this way, the objective of this work was to characterize the cotton crop in the Mato Grosso State using LSPA data series of area, production, productivity for micro-regions as well as mesoregions. In addition, meteorological data was included to explain possible causes of yield productivity variation.

Materials and methods

The State of Mato Grosso is located in the Central-West region of Brazil, between the coordinates 06°00' S and 19°45' S and 50°06' W and 62°45'W, with an area of 903,357,908 km² (Figure 1). The State has three biomes, the savanna, the Amazon rainforest and the Pantanal (IBGE, 2020). According to the Koppen climate classification (Chen and Chen, 2013), two characteristic climates predominate in the region: Aw and Cwa, with rainfall accumulations in summer and autumn, and water scarcity in spring and winter (Souza et al., 2013).

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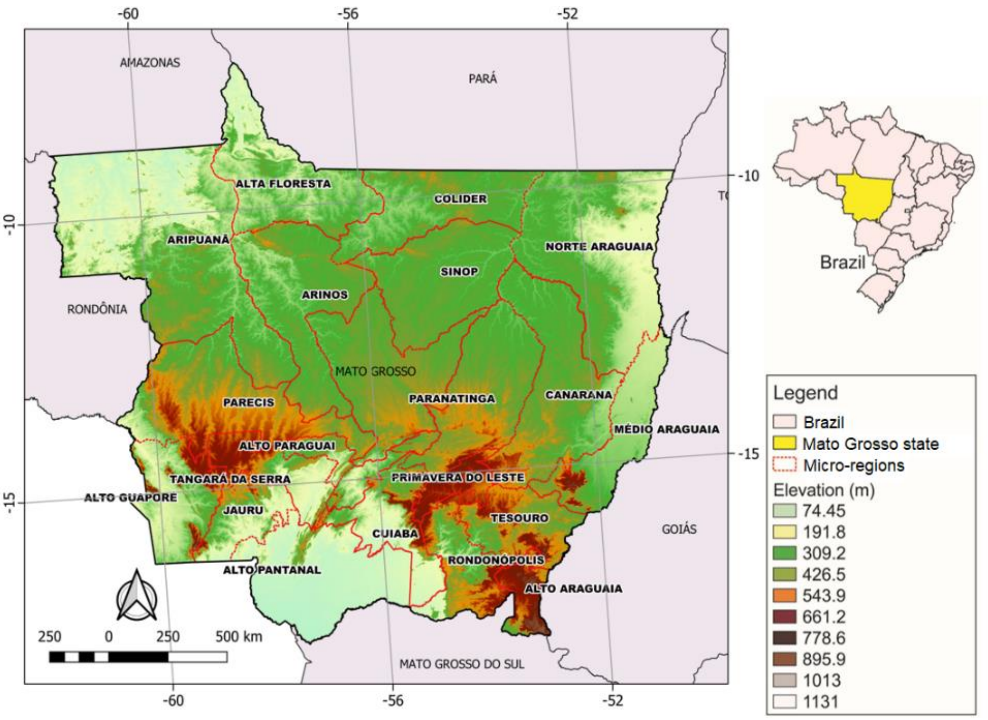

Figure 1. Elevation (m) in the different micro-regions of Mato Grosso State.

The cultivated area and cotton production were obtained through the database of the IBGE, denominated LSPA (Junges et al., 2012). The data series was from the period between 2005 to 2016 for the Northern, Northeastern, Southwestern, Southern, Southeastern mesoregions as well as micro-regions of Mato Grosso.

Monthly rainfall data were obtained from the Tropical Rainfall Measuring Mission (TRMM) satellite. This satellite generates data with a spatial resolution of about 30 km and rainfall estimates every three hours (NASA, 2016). Rainfall data for the State were generated using Goltz et al. (2007) methodology. The GEOS-5 satellite provided data on the average air temperature. The data can be found at https://giovanni.gsfc.nasa.gov/giovanni/.

QGIS v.2.18.15 software was used to collect data in NetCDF format. Monthly and semiannual (January to June) cumulative rainfall and monthly mean air temperatures were calculated (De Almeida et al., 2015). The limits of the mesoregions and microregions to perform graphs were obtained from IBGE.

The seed cotton yield was calculated by dividing the total amount produced in the region by the total area harvested. A graph was constructed with the time series of production and yield productivity. Descriptive statistics such as mean, median, standard deviation and coefficient of variation were also determined for the mesoregions and micro-regions.

Results and discussion

The planted area and cotton production decreased in 2013 and 2014 in most of the micro-regions of Mato Grosso (Figure 2). The northern microregions were the most productive during the period studied (Figure 2A and 2B) and the microregion with the highest productive peak and largest area was Parecis in 2016 (137000 ha and 515000 Mg produced). Furthermore, the southeastern microregions maintained stability in both areas and production (Figure 2G and 2H). On the other hand, the lowest values in area and production were recorded in the Central-South mesoregion. This could be due to the fact that in Alto Pantanal, Alto Paraguai, and Rosario Oeste in certain years, there were no records of the crop (Figure 2E and 2F).

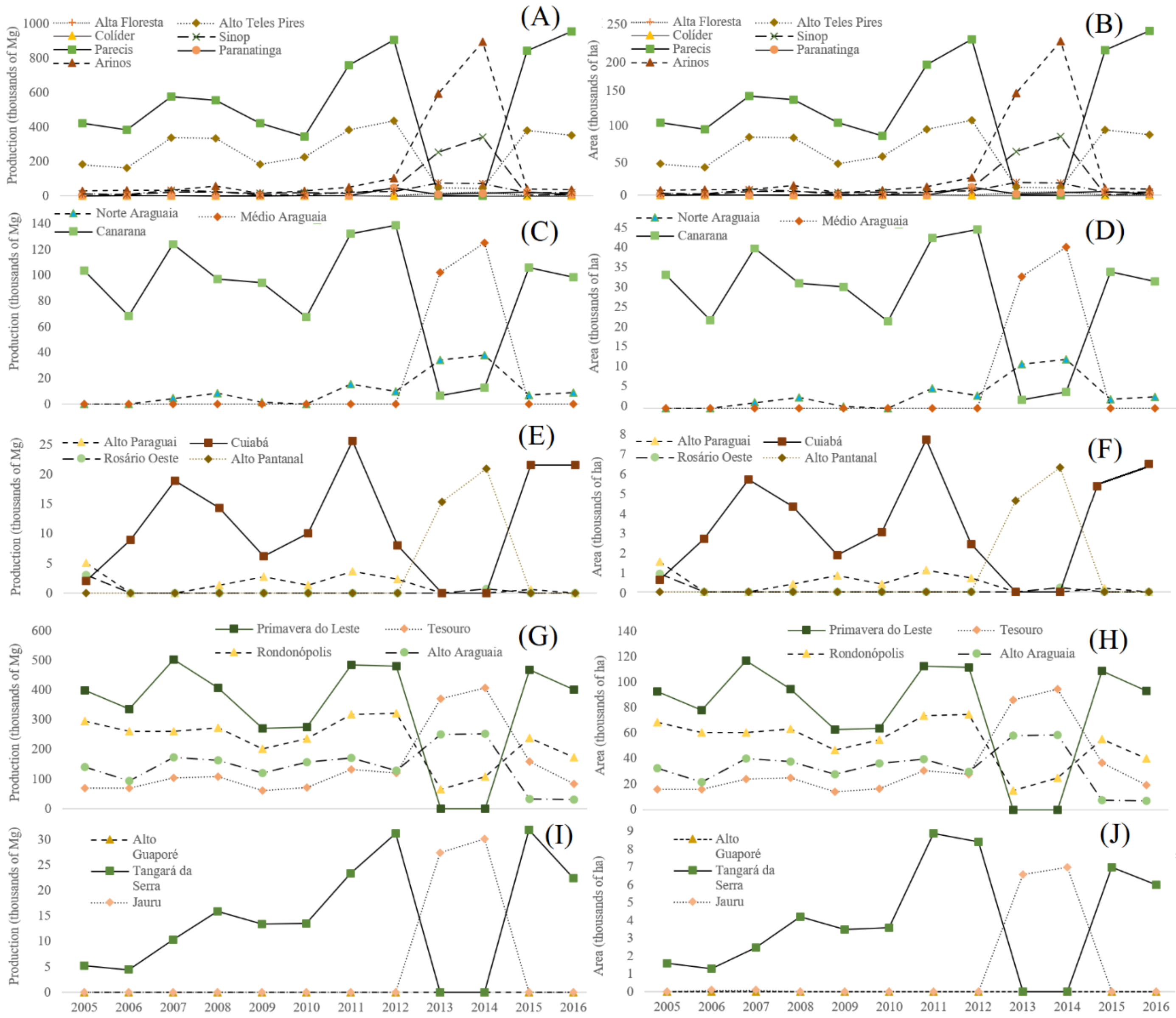

Figure 2. Yearly cotton production (left) and cultivated area (right) in Mato Grosso micro-regions.

Cotton planted area increased until 2012 as a result of high demand and, in some cases, scarcity (IMEA, 2011). On the other hand, the decrease in planted area after the 2011/2012 harvest was due to three reasons: low competition with soybean and corn, the risk associated with biotic and abiotic factors and competition with substitute materials for cotton fiber (IMEA, 2012).

Overall, the northern and southeastern regions are responsible for the largest amount of cotton produced (Figure 3A). It was observed that production in the northern region grew by 60% during the analyzed period, reaching 1600000 Mg of seed cotton in 2016. The micro-region of Rondonópolis presented a CV of 27% (Figure 3B), being the most stable in the quantity of seed cotton produced. On the other hand, the greatest variations, for example, in Médio Araguaia may be caused by extreme fluctuations in the planted area.

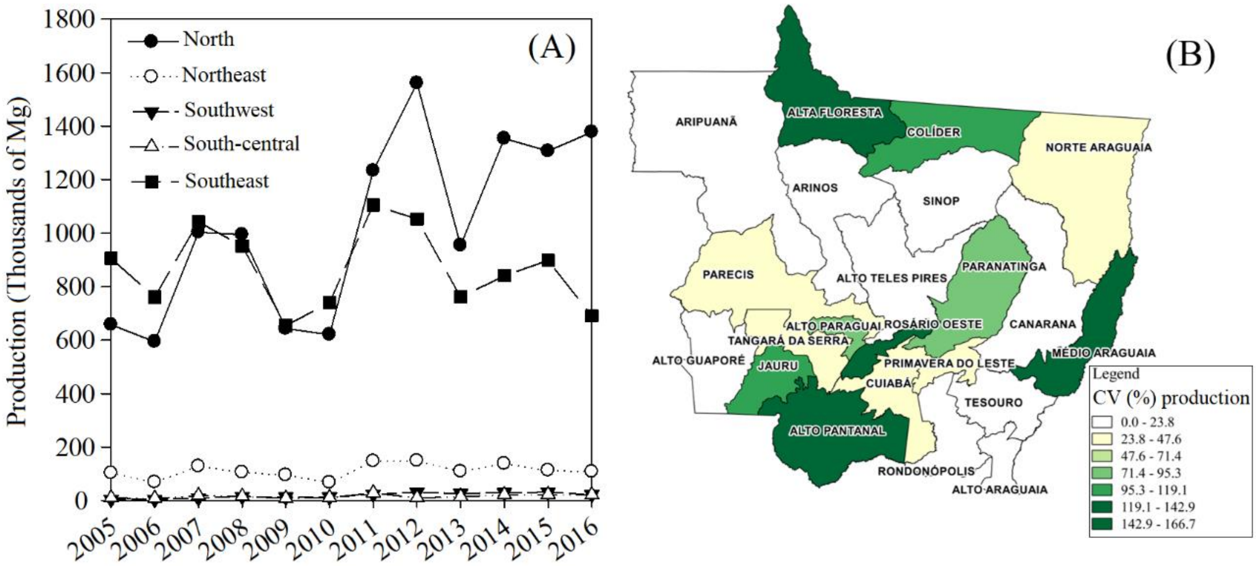

Figure 3. Yearly cotton production in Mato Grosso mesoregions (A) and production variations between 2005 and 2016 in the micro-regions (B).

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Average productivity ranged between 3.51 Mg ha^{-1} in the south-central region and 3.89 Mg ha^{-1} in the southeastern region. Overall, productivity values remained stable in all the mesoregions (Figure 4B). However, in 2011, productivity decreased in the southwestern and south-central regions (Figure 4A). On the other hand, in addition to having the largest area and production, Parecis has high productivity (Figure 4B).

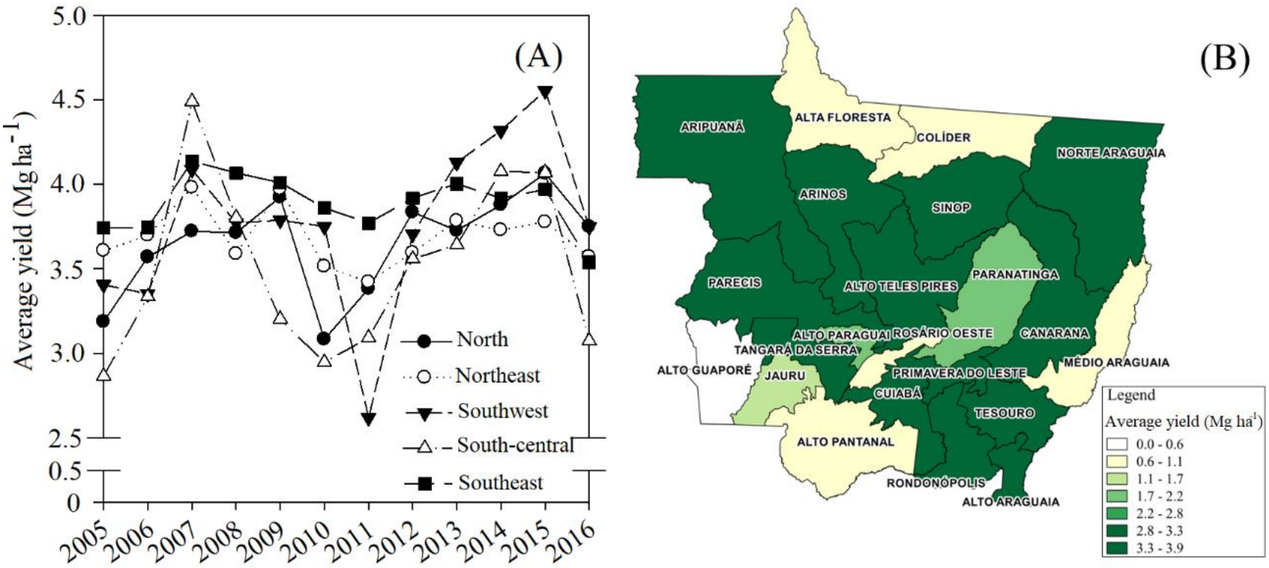

Figure 4. Yearly cotton productivity in Mato Grosso mesoregions (A) and average yield between 2005 and 2016 in the micro-regions (B).

The Northern mesoregion presents the highest value of revenue per seed cotton (R$3 million), followed by the Southeastern mesoregion (R$1.5 million) (Figure 5). The micro-regions of Parecis and Primavera do Leste, in the Southeast region, received the highest revenue from seed cotton ($1000) in the entire State, while Rosário Oeste reported no revenue.

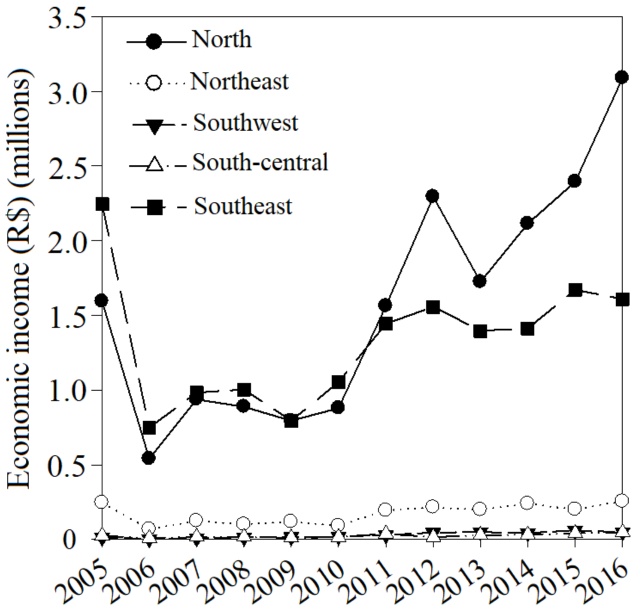

Figure 5. Yearly economic income in Mato Grosso mesoregions.

Several factors can influence price formation. According to Alves et al. (2008), the creation of substitute materials for the use of fiber directly influences the formation of internal and external cotton prices. Thus, the fluctuation of the market could influence the accentuated decreases or increases in the planted area, demanding the use of advanced technology to reduce the cost of production.

The temperature data series indicates that the minimum mean temperature recorded in the period studied was 20.1 °C and the maximum mean temperature was 28.2 °C. Cotton productivity is directly related to temperature (Wanjura et al., 1969). For example, high temperature interferes with physiological processes, water relations, and lint yield production, while low temperature inhibits fiber elongation in the initial phase of growth. In this way, Sarwar et al. (2019) reported that the optimal temperature for cotton is between 20 and 30°C. Therefore, the results suggest that all microregions had an ideal temperature for cotton development during the period studied.

According to Bezerra et al. (2012), the water demand for cotton ranges from 700 to 1250 mm in the semiarid region of Brazil. In 2011, cumulative rainfall during the cotton crop cycle ranged from 1079-1383 mm and in 2012 from 1002-1370 mm (Figure 6). However, the southwestern mesoregion showed a significant reduction in productivity (Figure 3A). For example, in the Tangará da Serra micro-region, yields decreased from 3.8 to 2.6 Mg ha^{-1}. This could be caused by the rainfall distribution pattern in this region. During fiber elongation, this microregion was affected by water scarcity (8.4-23.3 mm). On the contrary, at the same phenological stage in 2012, precipitation in Tangará da Serra ranged from 126 to 206 mm.

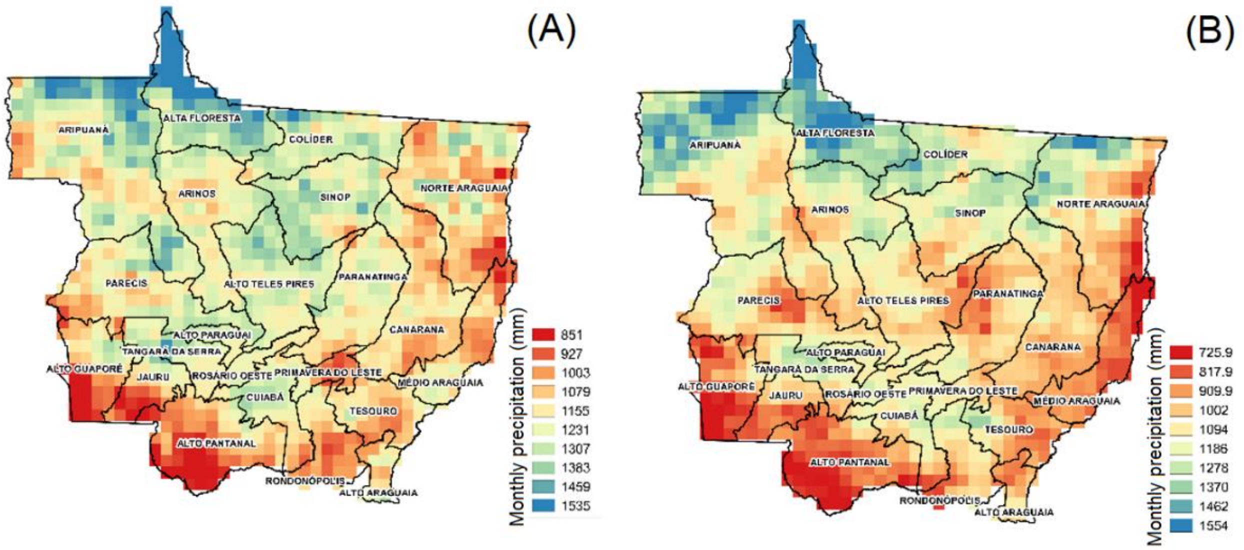

Figure 6. Accumulated precipitation (January to June) in Mato Grosso State in 2011 (A) and 2012 (B).

Conclusions

The highest average productivity between 2005 and 2016 was recorded in the Alto Araguaia, Parecis and Rondonópolis microregions with an average of 3.9 Mg ha^{-1}.

Rainfall distribution suggests that yield penalty is caused by water scarcity in critical periods of cotton development.

Variations in economic income during the period 2005 to 2016 were produced mainly by changes in planted area.

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