

## Agroclimatic zoning of the state of Minas Gerais for the production of high quality soybean seeds<sup>1</sup>

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**ABSTRACT** – In Brasil, Minas Gerais is the sixth state in soybean production. Adverse climatic conditions such as short mini-droughts (“veranicos”), irregular rainfall distribution and especially high temperatures can compromise the proper development of the crop in that state, especially in relation to the production of high quality seeds. The aim of this study was to collect and analyze data in order to establish an agro-climatic zoning of the state of Minas Gerais for the production of high quality soybean seeds. These values were georeferenced in terms of the latitude and longitude coordinates and, with the use of a geographic information system, a thematic map was created, in which the best growing regions in Minas Gerais are represented. The definition of higher or lower climate risk areas was associated with the occurrence of average temperatures during the seed maturation phase, the most sensitive stage of growth. On the basis of the data obtained on temperature and altitude of different locations, and considering the normal growth period, it was possible to outline a map with three distinct areas: Favorable - average temperature  $\leq 23,5$  °C; moderately favorable - average temperature between 23,6 °C and 24,9 °C; Unfavorable - average temperature  $\geq 25,0$  °C.

Index terms: *Glycine max* (L.) Merrill, thematic map, production regions, temperature.

## Zoneamento agroclimático do estado de Minas Gerais para a produção de semente de soja de alta qualidade

**RESUMO** - Minas Gerais é o sexto estado em produção de soja no Brasil. Adversidades climáticas como veranicos, distribuição irregular das chuvas no decorrer do ano e principalmente temperaturas elevadas podem comprometer o bom desenvolvimento da cultura no Estado, principalmente no que se refere à produção de sementes de elevada qualidade. Diante disso, o objetivo desse estudo foi realizar um levantamento de dados com a finalidade de estabelecer um zoneamento agroclimático para a produção de sementes de soja de elevada qualidade física e fisiológica. Esses valores foram georeferenciados em função da latitude e longitude e, com o uso de um sistema de informações geográficas, foi confeccionado o mapa temático no qual estão representadas as melhores regiões para semeadura da cultura no Estado. A definição das regiões de maior ou menor risco climático foi associada à ocorrência de temperaturas médias na fase de maturação da soja, considerada a fase de máximo potencial fisiológico da semente, e da altitude dos municípios, tudo isso considerando a época normal de semeadura da cultura. Com base nos levantamentos realizados, estabeleceram-se três classes de regiões: Favorável – temperatura média  $\leq 23,5$  °C; Medianamente Favorável - temperatura média entre 23,6 °C a 24,9 °C; Pouco Favorável - temperatura média  $\geq 25,0$  °C.

Termos para indexação: *Glycine max* (L.) Merrill, mapa temático, regiões de produção, temperatura.

### Introduction

Brazil's soybean yield in 2013/14 set a new record as the production reached more than 86 million tons, the result of approximately 30 million hectares devoted to cropland. In this harvest, Minas Gerais was the sixth state in soybean

production in Brazil, harvesting about 3.3 million tonnes, a fruit of 1,238 million hectares cultivated (CONAB, 2014). Adverse climatic conditions such as availability of water content, short mini-droughts (“veranicos”), irregular rainfall distribution throughout the year and particularly high temperatures can compromise the proper development of the

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crop in that state, especially in relation to the production of high quality seeds.

In Brazil, from the 1996/97 harvest, the Ministry of Agriculture, Livestock, Food and Supply (MAPA) has conducted studies about applied climate risks in agriculture known as “Agroecological Zoning in Brazil”. According to Evangelista et al. (2013), agricultural zoning has been used as an instrument of agricultural policy and risk management in agriculture and it started contributing significantly to increase the national agricultural production and reduce yield losses due to climate variability.

A successful soybean crop depends on several factors, but undoubtedly the most important of them is the use of high quality seeds, producing strong, vigorous plants, with superior performance in the field (França-Neto et al., 2014), tolerating potential stresses arising from different environmental conditions (soil and climate). On the other hand, medium or low-vigor seeds and deteriorated seeds result in weak seedlings with little or no chances of success in establishing themselves competitively (Krzyzanowski et al., 2008). The use of good quality seeds enables access to genetic advances, with quality assurance and localization technologies in different regions, ensuring higher productivity. Therefore, the soybean crop establishment with high quality seeds is of key importance.

The production of high quality seeds requires that the maturation and harvesting phases occur under mild temperatures [Costa et al. (2003, 2005a; 2005b); França-Neto et al. (2007); Embrapa (2013)], associated with dry weather conditions. As Marcos-Filho (2005) highlighted, the concept of maturity, on the basis of seeds dry mass, constitutes a reference point to characterize the termination of seed development processes, and is considered the stage of maximum seed physiological potential.

To produce high quality soybean seeds, it is ideal that the average temperature during maturation and harvesting stages, is equal to or less than 22 °C (Embrapa, 2013). Such conditions are not easily found in tropical regions, but can occur in areas located above 700 m altitude, or with the adjustment of sowing time for seed production (França-Neto et al., 2007). In regions of latitudes further south 24°, climate conditions are more conducive to produce high quality soybean seeds (Costa et al. 2003; 2005b).

Obtaining high quality seeds can be very problematic in most tropical regions, like in Brazilian soybean producers, specifically those north of the 24° parallel. According to Costa et al. (2003; 2005a; 2005b), in this locations, frequent climatic oscillations affect substantially the quality the quality seed production. The major causes of reduced quality seeds are constant fluctuations in temperature and rainfall distribution

during the maturation phase, and seed deterioration may be exacerbated, especially if these conditions are associated with temperatures above 24 °C (Costa et al., 1994).

In this context, agroclimatic zoning for high quality seeds production stands out for its importance, since through it, producers can more safely allocate their production fields in regions where climatic conditions are more favorable for seed production.

In Minas Gerais, the first surveys to identify the most favorable areas for soybean seeds production of soybean regions were carried out by Paolinelli et al. (1984), evaluating the physiological quality, and Tanaka et al. (1984), assessing the sanitary quality in five different regions and micro-regions of the state: Pontal and Vale do Rio Grande (Triângulo Mineiro); Alto Paranaíba; Metallurgical region (Central) and Paracatu region (Northwest). Four years later, Costa et al. (1988) conducted a study to evaluate the physiological quality of 16 genotypes in three regions: Triângulo Mineiro, Paracatu and Alto Paranaíba. In 2000, Santos et al. (2000) evaluated the physiological and sanitary quality of soybean cultivars and lines in three regions: Capinópolis (Triângulo Mineiro), Rio Paranaíba (Alto Paranaíba) and Florestal (Central).

In Brazil, a pioneering study was conducted by Embrapa Soja for the state of Paraná, in which the ecological zoning for seed production of early maturing soybean cultivars was performed (Costa et al., 1994).

Due to a lack of information and considering the importance of making available a detailed zoning in state of Minas Gerais, the aim of this study was to undertake a survey data collection to establish an agroclimatic zoning for the production of high quality soybean seeds.

## Material and Methods

The study was conducted in the Seed Analysis Laboratory located at the Triângulo and Alto Paranaíba EPAMIG Unit (URETP), in Uberaba - MG, in partnership with Embrapa Soja, Londrina- PR, the Geoprocessing Laboratory at the Federal Institute of Education, Science and Technology of Triângulo Mineiro (IFTM).

Data processing was performed using the SPRING geographic information system (Câmara et al., 1996), in which the thematic map of agroclimatic zoning was made, representing the best soybean growing regions in the state of Minas Gerais.

The definition of higher or lower climate risk areas was associated with the occurrence of average temperatures during the month of March, when soybean maturation and pre-harvest phases take place, both considered the most sensitive stages of growth and when the main goal is seed

production. All of this, if one takes into account the “normal” growing season. Temperature data for that month during a 39-year period, provided by INMET (2011), were considered.

In order to create the thematic map, Geominas database (INPE, 2013), seasonal rainfall data and an isotherm map corresponding to a 29-year period (INMET, 2011) were used. For spacialization, temperatures were associated with the geographic location of each municipality, where the program LEGAL (Spatial Language for Algebraic Geoprocessing), available in SPRING software (Georeferenced Information Processing System), was used through Digital Model Elevation – MNT generation, and data slicing and association into thematic classes. Assad et al. (2001) and Lima et al. (2011) used similar methodological tools and procedures with excellent results.

## Results and Discussion

Data on soybean production and productivity in 2012/13 and the estimated production and productivity for 2013/2014, according to the July/2014 survey (CONAB, 2014) are presented in Table 1. The largest producer, Mato Grosso, showed an increase of 10.2% over the 2012/13 harvest, which can be associated with a climate condition that did not compromise the crop development, besides a productivity growth rate of 1.5%. Paraná, the second largest producing state, displayed significant reductions in productivity due to a long period of drought and high temperatures. In the case of the state of Rio Grande do Sul, a bad rainfall distribution throughout the cycle hindered crop development, causing a 4% reduction in productivity.

Table 1. A comparison between soybean production, productivity, 2012/13 and 2013/14 harvests, and soybean seed utilization rate (SUR) in seven Brazilian producing states.

State	Production (mil t) <sup>1</sup>		Productivity (kg/ha) <sup>1</sup>		SUR <sup>3</sup> (%)
	2012/13	2013/14 <sup>2</sup>	2012/13	2013/14 <sup>2</sup>	
MT	23.533	27.010	3.010	3.135	78
PR	15.912	14.805	3.348	2.950	60
RS	12.535	12.868	2.714	2.605	31
GO	8.563	8.637	2.965	2.808	75
MS	5.809	6.148	2.880	2.900	69
MG	3.375	3.299	3.010	2.664	65
BA	2.692	3.229	2.100	2.460	73
Brazil	81.499	86.273	2.938	2.865	64

Source: <sup>1</sup>CONAB, <sup>2</sup>Estimate, July/2014; <sup>3</sup>ABRASEM, 2013.

The state of Minas Gerais, that ranked sixth in Brazil in this oilseed production, also showed significant losses in yield (Table 1), due to drought associated with high temperatures. It is necessary that Minas Gerais producers use available technologies to improve soybean production. According to França-Neto et al. (2012), environmental stresses such as high temperatures, especially when associated with short mini-droughts, may impair the proper development of the crop, especially in relation to the production of high quality seeds.

In addition to the available technologies choices for farmers, seed utilization rate (SUR) is of fundamental importance. According to ABRASEM (2013), in Minas Gerais SUR is actually 65%, a similar rate to that found at a national level (Table 1). On the other hand, 35% of soybean crops in the state are being established with low quality seeds. The increase in the seed utilization rate represent a reflection of producer's awareness about the physical and physiological quality of seeds, the source of seeds used and their sanity.

Costa et al. (2003, 2005b) conducted a survey on the profile of physical, chemical and physiological aspects of soybean seeds produced in six different Brazilian regions. They found that, in Minas Gerais, deterioration caused by moisture, mechanical damage and plant bug lesions exacerbated some serious problems relating to low quality seeds.

Among the available technological choices offered by research advances, producers have access to the best varieties and technologies for crop establishment and management. As the seed quality is the foundation of successful farming, agroclimatic zoning adds value to production in defining the most conducive areas; consequently, seed producers can obtain top quality products and high productivity.

A study carried out by Costa et al. (1994) with early maturing soybean cultivars found that there are more conducive areas in the state of Paraná for top quality seed production, and they have elaborated an ecological zoning of the state of Paraná. Subsequently, Costa et al. (2005a) validated an ecological zoning, pointing to the south area of

Paraná as the one with the best climate conditions to produce seeds with higher physiological quality.

França-Neto et al. (2007) states that high quality seed production requires that the maturation and harvesting phases occur under mild temperatures (around 22 °C) associated with dry conditions. Due to the fact that the state of Minas Gerais is located north of the 24° parallel, in order to define the thematic classes three temperature ranges were assigned, averages for

the month of March, establishing three different categories of climate risk areas: favorable - average temperature  $\leq 23,5$  °C; moderately favorable - average temperature between 23,6 °C and 24,9 °C; unfavorable - average temperature  $\geq 25,0$  °C.

Based on surveys, three distinct regions were delineated on Minas Gerais map. Figure 1 shows the distinct regions as: favorable (in green); moderately favorable (in yellow) and unfavorable (in orange).

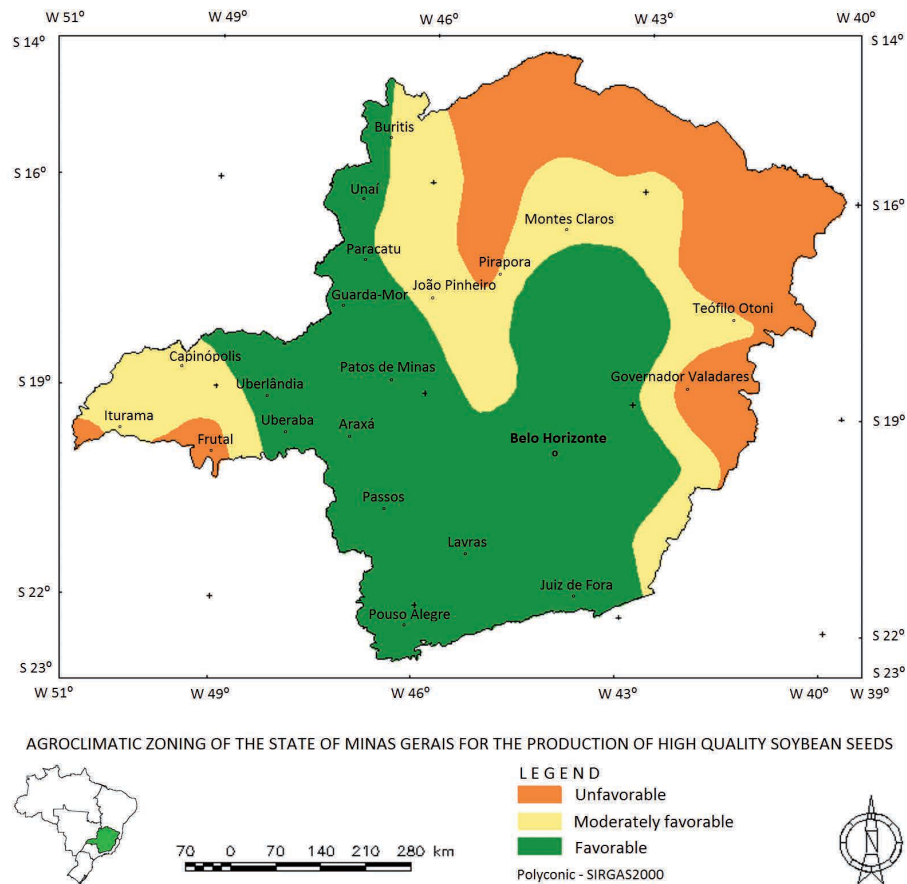


Figure 1. Minas Gerais map containing agroclimatic zoning areas for the production of high quality soybean seeds. Favorable – in green ( $\leq 23,5$  °C); Moderately favorable – in yellow (between 23,6 °C and 24,9 °C); and Unfavorable – in orange ( $\geq 25,0$  °C).

The favorable areas include Alto Paranaíba region, part of Triângulo Mineiro, part of the Northwestern region, South Minas Gerais, Midwest region and part of the Central region. Preliminary researches on the soybean seeds quality carried out in Minas Gerais by Paolinelli et al. (1984), Tanaka et al. (1984) and Santos et al. (2000) concluded that the best quality soybean seeds are produced in the Alto Paranaíba region. Additional studies were performed by Costa et al. (1988), who concluded that seeds produced in Presidente Olegario (Northwest), Uberlândia (Triângulo Mineiro) and Coromandel (Alto Paranaíba), higher altitude locations, showed better physiological quality

in seeds. These data corroborate the information contained in the map elaborated and presented in this study.

According to data on Table 2, in 2003, it was found that Alto Paranaíba region represents 20.3% of the total area of the state, while the Triângulo Mineiro represents 34.8% of the area, with particular reference to Uberaba, the second largest producing municipality in the state, followed by Uberlândia (6<sup>th</sup> largest producer in Minas Gerais), Monte Alegre de Minas (7<sup>th</sup>), Tupaciguara and Araguari. Minas Gerais northwest region accounts for 36.7% of the total area, with emphasis being placed on Unai (Minas Gerais largest producer),

followed by Paracatu (3<sup>rd</sup>), Buritis (4<sup>th</sup>) and Guarda-Mor (in 5<sup>th</sup> place). Other regions classified as “favorable” represent only 8.2% of the state’s production (SEAPA, 2013).

Table 2. Main soybean producing municipalities by region and related to the harvested area in the state of Minas Gerais in 2013.

Ranking	Municipality	Region	Relation (%)
1°.	Unai	Noroeste de Minas	10.14
2°.	Uberaba	Triângulo Mineiro	7.14
3°.	Paracatu	Noroeste de Minas	6.96
4°.	Buritis	Noroeste de Minas	6.61
5°.	Guarda-Mor	Noroeste de Minas	4.61
6°.	Uberlândia	Triângulo Mineiro	4.18
7°.	Monte Alegre de Minas	Triângulo Mineiro	3.92
8°.	Coromandel	Alto Paranaíba	3.74
9°.	Tupaciguara	Triângulo Mineiro	2.44
10°.	Sacramento	Alto Paranaíba	2.35
11°.	Capinópolis	Triângulo Mineiro	2.31
12°.	Perdizes	Alto Paranaíba	2.18
13°.	Conceição das Alagoas	Triângulo Mineiro	2.18
14°.	Formoso	Noroeste de Minas	1.96
15°.	Nova Ponte	Alto Paranaíba	1.83
16°.	Bonfinópolis de Minas	Noroeste de Minas	1.74
17°.	Ibiá	Alto Paranaíba	1.74
18°.	Prata	Triângulo Mineiro	1.72
19°.	Araguari	Triângulo Mineiro	1.70
20°.	Presidente Olegário	Noroeste de Minas	1.35
Total harvested area		Region	Area (%)
		Noroeste de Minas	36.7
		Triângulo Mineiro	34.8
Minas Gerais		Alto Paranaíba	20.3
		Other	8.2

Source: IBGE/SEAPA, 2013.

The area considered “moderately favorable” includes part of Triângulo Mineiro (municipalities of Capinópolis, Conceição das Alagoas, Prata); part of the Northwest region (municipalities of Formoso, Bonfinópolis de Minas); part of the Central region and small parts of Zona da Mata and Northern region. In line with these data, Santos et al. (2000) found that soybean seeds produced in Capinópolis town had lower quality than seeds produced in Alto Paranaíba, a result that, once again, reinforces the reliability of the information exhibited in the map of the present study.

Finally, the unfavorable area is concentrated in Northern Minas Gerais, in Jequitinhonha and Rio Doce regions.

## Conclusions

In the state of Minas Gerais there are more conducive agroclimatic zones to produce high quality soybean seeds.

Through agroclimatic zoning, three types of producing regions were established: Favorable - average temperature  $\leq 23,5$  °C; moderately favorable - average temperature between 23,6 °C and 24,9 °C; unfavorable - average temperature  $\geq 25,0$  °C.

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