SOYBEAN PRODUCTION IN THE MUNICIPALITY OF CASCAVEL - PR:
RAINFALL INDICES AS THE MAIN INFLUENCE FACTOR

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ABSTRACT

Objective: This work presents factors that influence soybean production in various scenarios, more specifically in Cascavel-PR, between the summer seasons 2016/17 to 2022/23.

Theoretical reference: Soy production is an economic activity with great potential in Brazil and, especially, in the state of Paraná. The climatic conditions present great challenges for the producers, since different factors (shortage of chuvas, high temperatures and the incidence of rain and diseases) affect the development of culture.

Method: Foram pointed out and made comparisons in the production of comfort in various contexts, cultivation areas and relevant information on the climate, specifically as rainfall precipitations below or above the average in various stages of culture in the municipality of Paranaense, and consequently, as oscillations in the summer holidays. They are used in literature, articles, information on sites, magazines and data from governmental organizations (federal and state), with quantitative and qualitative analyses, using the Sisvar software.

Results and conclusion: Among the factors analyzed, climate as the main agent of influence in soybean production.

Implications of the research: To minimize the impacts on productivity and its consequences in regional/economic development, it is necessary to review management techniques at the sole, plant, new technologies and also at the global level; o aquecimento, o dematamento that influences the increase in temperatures and the incidence of rain.

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Originality/value: Analyzing two rainfall indices and their relationships with agricultural cultures is crucial to guarantee healthy and productive production. It allows farmers to adapt their management practices, make informed decisions and minimize the risks associated with varying climatic conditions.

Keywords: Climate, Grão, Chuva, Performance.

PRODUÇÃO DE SOJA NO MUNICÍPIO DE CASCAVEL - PR: ÍNDICES PLUVIOMÉTRICOS COMO PRINCIPAL FATOR DE INFLUÊNCIA

RESUMO

Objetivo: O presente trabalho apresenta fatores que influenciaram a produção de soja em diversos cenários, mais especificamente em Cascavel-PR, entre as safras de verão 2016/17 a 2022/23.

Referencial teórico: A produção de soja é uma atividade econômica com grande potencial no Brasil e, em especial, no estado do Paraná. As condições climáticas apresentam grandes desafios para os produtores, sendo que diferentes fatores (escassez de chuvas, as altas temperaturas e a incidência de pragas e doenças) afetam o desenvolvimento da cultura.

Método: Foram apontadas e realizadas comparações na produção da comodity em diversos contextos, áreas de cultivo e informações relevantes sobre o clima, em específico as precipitações pluviométricas abaixo ou acima da média em vários estágios da cultura no município paranaense, e consequentemente, as oscilações nas safras de verão. Foram utilizadas na literatura, artigos, informações em sites, revistas e dados de órgãos governamentais (federais e estaduais), com análises quantitativas e qualitativas, em meio ao software Sisvar.

Resultados e conclusão: Dentre os fatores analisados o clima como o principal agente de influência na produção de soja.

Implicações da pesquisa: Para minimizar os impactos na produtividade e suas consequências no desenvolvimento regional/econômico é necessário rever técnicas de manejo do solo, plantio, novas tecnologias e também no âmbito global; o aquecimento, o desmatamento que influencia no aumento das temperaturas e na incidência das chuvas.

Originalidade/valor: Análise dos índices pluviométricos e suas relações com as culturas agrícolas é crucial para garantir uma produção saudável e produtiva. Ela permite aos agricultores adaptar suas práticas de manejo, tomar decisões informadas e minimizar os riscos associados às condições climáticas variáveis.

Palavras-chave: Clima, Grão, Chuva, Rendimento.

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1 INTRODUCTION

Soybean production is an economic activity of great importance in Brazil and in particular in the state of Paraná (MAPA, 2022). The state is one of the main soybean producing regions in Brazil and the world, outstanding for its high productivity and grain quality. According to the DERAL (Department of Rural Economy) and the SEAB (Secretary of State for Agriculture and Supplies) the crop estimate of 2022/23 in Paraná is that 5.76 million hectares are planted, reaching a production of 22.37 million soybeans.

However, climatic conditions present challenges for producers, who need to deal with different factors that affect the development of the crop, such as the scarcity of rain, high temperatures and the incidence of pests and diseases.
Consequently, it becomes necessary to understand how these climatic conditions affect the production of soybeans in the western region of Paraná, in particular in Cascavel-PR. It is worth noting that this region also suffers from the influences of El Niño and La Niña, causing variations in temperatures and the amount of rainfall during the grain cycle (SALTON, 2021).

According to Tosin (2005), the climate in Diamondback is characterized by summers with high and humid temperatures and mild and dry winters. These climatic variations favor the cultivation of soybeans, but they also present challenges such as: (a) the occurrence of excessive rainfall or (b) prolonged droughts that can negatively impact production.

In this bias, in the present work, bibliographic research and mining data were done in governmental bodies (Federal and State) on the grain production, from the Brazilian regions to the municipality of Cascavel-PR. In addition, data on pluviometric volumes in the commodity cycle were collected, and tabulated and analyzed via descriptive and inferential statistics (through electronic spreadsheets and software Sisvar).

In this sense, the objective of this article is to verify how adverse conditions affect the production of soybeans, in particular the rainfall rates in the South of Brazil, more specifically in the municipality of Cascavel-PR.

2 THEORETICAL GROUNDS

The production of soybeans in the West of Paraná is one of the main economic activities of the region, with high productivity and profitability (FERREIRA, 2019), that is, they bring relevant socio-economic implications, since they generate jobs and income for the population.

According to data from the National Supply Company - CONAB (2022), the production of soybeans in Cascavel in the 2020/2021 harvest was estimated at 1.31 million tons, being the city the second largest producer in the state of Paraná, behind only Toledo.

Therefore, it is worth noting that the regularity of the rains and the humid climate are important factors that imply the quality and productivity of soybeans (ALVES, 2019), but also, it is worth remembering that this agriculture is highly dependent on the climate, in particular the rainfall (SALTON, 2021) and the composition of the soil (ZANATTA, RIZZI and SCHOR, 2022; INÁCIO and CORTEZ, 2023).

Climate variability has been one of the main factors affecting soybean production in Western Paraná, especially in recent years, with extreme weather events such as prolonged droughts and heavy rains (CORDEIRO, 2019). Farias (2019) adds that the favorable climatic conditions are hot and humid summers, which provide a favorable environment for planting crops, but also present challenges such as droughts and high and/or low rainfall rates.

With regard to excessive rainfall, it can cause soil soaking, preventing the growth of soybean roots and increasing the incidence of plant diseases. On the other hand, prolonged droughts can reduce productivity and affect grain quality. High temperatures and humidity during summer can also favor the emergence of pests and diseases in plants, which can affect production (SILVA, 2019).

Some of these variations are caused by the phenomenon El Niño (which causes the cooling of the pacific waters) and La Niña (which causes the warming of the pacific waters); which influence the formation of winds and atmospheric pressure, leading to a lack of control in the rainy periods (SALTON, 2021).

Previous research has shown the possibility of losses in the cultivation of soybeans in Brazil, which run the risk of reaching 40% in the next 100 years, and could bring an annual loss of R$ 4.3 billion (projection raised by the IPPC - Intergovernmental Panel on Climate Change and by FAPESP's Pesquisa Magazine, 2009). In the midst of this estimate, soybean production will be the crop that will suffer most from the increases in temperatures, impacting the southern region of Brazil.
In short, the production of soybeans in Cascavel-PR, is strongly dependent on the climatic conditions. The great climatic variability in this region makes soybean production a constant challenge for producers. According to Salton (2021), understand the phenomenon of drought, its possible causes and impacts are important to establish water security and propose alternatives for adaptation and mitigation of its effects. Thus, the quantitative, spatial and temporal characterization of dry periods can minimize the losses generated by this weather, including those related to agriculture.

To establish a link between production and the climatic factor (rainfall index) descriptive, inferential and experimental statistical analysis tools (Sisvar and spreadsheets) will be used to verify the involvement of these in the agricultural production of summer, in particular in soybeans in the municipality of Cascavel-PR.

3 METHODOLOGICAL PROCEDURES

The information obtained for the basis of the research, were mined from tables of organs such as IBGE, CONAB, DERAL, SEAB-PR, IAT-PR, among others, for the purpose of having reliable information. With these data, analyzes and discussions were carried out, using statistical tools that verified whether there is a correlation between rainfall and soybean productivity in the municipality of Cascavel-PR.

To identify significant differences between production and pluviometric indices, the Anova-Tukey Test (p) and the Linear Regression Test (r²) were applied. After the analyzes, the data was compiled in Excel and in the software statistical Sisvar (developed by Daniel Furtado Ferreira, from the Federal University of Lavras).

From the point of view of the approach of this study, the data and results are of qualitative and quantitative characteristics.

4 DEVELOPMENT

Soybeans are an important crop both in Brazil and in the world. According to Nogueira (2023), Brazil, the United States and Argentina are the largest soybean producers in the world. Leaders in the world production of the grain for more than 15 years, the countries together produce more than 320 million tons of soybeans per crop, and for about four years Brazil has occupied the first place in the international ranking of soybean production.

According to Nogueira (2023), still about Brazilian production, more than 10 million hectares are located in Mato Grosso, the Brazilian state that most produces the grain. Rio Grande do Sul, Paraná and Goiás also stand out in the production of soybeans. It is worth pointing out that the participation of the Maranhão region, has high growth potential and is today the great frontier for the expansion of soybean production in Brazil (NOGUEIRA, 2023).

Soybeans are a very important commodity in the international market, being used mainly in the production of animal feed, as a source of protein. In addition, soybeans are used in oil production, cooking and the biodiesel industry. According to the Brazilian Association of Vegetable Oil Industries ABIOVE (2023), about 70% of the world's soybean production is destined for animal feed production.

Soybean production in Brazil has been a major driver of economic growth, especially in the Midwest and South of the country (IBGE, 2023). According to the Ministry of Agriculture, Livestock and Supply - MAPA (2022), Paraná is the second largest soybean producer in the country, behind only Mato Grosso. In 2020, the state produced about 20.5 million tons of soybeans, accounting for 18.4% of national production. The western region of Paraná is the largest producer of soybeans in the state, followed by the north and northwest regions. Soybeans are a very important crop for the economy of Paraná, contributing...
Significantly to the generation of employment and income in the field and to the exports of the state.

According to data from CONAB (2022), Paraná plays an important role in the production of soybeans for the internal and external supply of this commodity. Table 1 presents data on the production of the last 7 (seven) crops (with 2022/23 Forecast), with data from Brazil, by regions (especially the South) and with emphasis on the state of Paraná.

Table 1 - SOYBEANS - BRAZIL - Historical Production Series - Crops 2016/17 to 2022/23 (in millions of tons).

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</thead>
<tbody>
<tr>
<td>NORTH</td>
<td>5.536.5</td>
<td>6.012.6</td>
<td>6.147.0</td>
<td>6.902.1</td>
<td>7.384.0</td>
<td>8.379.9</td>
<td>9.547.3</td>
</tr>
<tr>
<td>NORTHEAST</td>
<td>9.644.7</td>
<td>11.903.1</td>
<td>11.034.9</td>
<td>11.819.6</td>
<td>12.852.2</td>
<td>13.876.9</td>
<td>15.208.9</td>
</tr>
<tr>
<td>MIDWEST</td>
<td>50.642.6</td>
<td>55.398.4</td>
<td>60.697.5</td>
<td>64.796.5</td>
<td>68.126.0</td>
<td>76.357.6</td>
<td></td>
</tr>
<tr>
<td>SOUTH-EAST</td>
<td>8.151.5</td>
<td>9.157.2</td>
<td>8.613.9</td>
<td>10.131.1</td>
<td>11.321.1</td>
<td>11.767.0</td>
<td>13.097.6</td>
</tr>
<tr>
<td>SOUTH</td>
<td>41.051.3</td>
<td>40.787.5</td>
<td>38.864.2</td>
<td>35.294.5</td>
<td>43.031.5</td>
<td>23.400.0</td>
<td>39.421.6</td>
</tr>
<tr>
<td>PR</td>
<td>19.922.2</td>
<td>20.044.9</td>
<td>16.921.5</td>
<td>21.598.1</td>
<td>19.880.1</td>
<td>12.250.3</td>
<td>22.300.7</td>
</tr>
<tr>
<td>SC</td>
<td>2.292.6</td>
<td>2.362.8</td>
<td>2.420.5</td>
<td>2.252.8</td>
<td>2.363.9</td>
<td>2.038.7</td>
<td>2.607.9</td>
</tr>
<tr>
<td>RS</td>
<td>18.836.4</td>
<td>18.379.8</td>
<td>19.522.2</td>
<td>11.443.6</td>
<td>20.787.5</td>
<td>9.111.0</td>
<td>14.513.0</td>
</tr>
<tr>
<td>BRAZIL</td>
<td>115.026.7</td>
<td>123.258.9</td>
<td>119.718.1</td>
<td>124.844.8</td>
<td>139.385.3</td>
<td>125.549.8</td>
<td>153.633.0</td>
</tr>
</tbody>
</table>

Key: (¹) Estimate as of April 2023.

Source: Adapted - CONAB/2023.

When comparing the data from Paraná in the last seven harvests, the state was responsible for 51.08% of the production of the southern region and 14.79% of the national production of soybeans; falling behind the central-west region.

Production in 2021/22 fell significantly, due mainly to the prolonged drought that plagued the state and the southern region. In the previous period, Rio Grande do Sul was the largest producer in the region, but was surpassed by Paraná in the next two crops.

After the survey of the data on the production of the last soybean crops, it is possible to determine the percentage and importance of the state of Paraná in the country on this production. In this bias, Table 2 presents comparisons confirming that the state continues growing and consolidating in agricultural production.

Table 2 - Percentage of soybean production in Paraná (Southern Region and Brazil).

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</thead>
<tbody>
<tr>
<td>For the Southern Region</td>
<td>48.53%</td>
<td>49.14%</td>
<td>43.54%</td>
<td>61.19%</td>
<td>46.20%</td>
<td>52.35%</td>
<td>56.57%</td>
</tr>
<tr>
<td>In relation to Brazil</td>
<td>17.32%</td>
<td>16.26%</td>
<td>14.13%</td>
<td>17.30%</td>
<td>14.26%</td>
<td>9.76%</td>
<td>14.52%</td>
</tr>
</tbody>
</table>

Key: (¹) Estimate as of April 2023.

Source: Adapted - CONAB/2023.

According to Table 2, the average between 2016/17 and 2022/23 is approximately 18.99 million tons, and the harvest 2016/17 and 2019/20 the state had a highlight in the national scenario, but in compensation the crop 2021/22 the numbers were far below the average. In relation to the southern region, the period 2019/20 is notable, and the state produced about 61.19% of the soybeans of the southern region, which corresponds to approximately 21.6 million tons.

By analyzing the area of planting factor (Table 3), it is possible to see few variations in the quantity of hectares destined to activity in the state of Paraná. On the national scenario, though, there is exponential growth, pulled by other regions of the country, with a highlight being the central region - west, mainly to the state of Mato Grosso.
Table 3 - SOYBEANS - Historical Series of Planted Area - Crops 2016/2017 to 2022/23 (in millions of hectares).

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</thead>
<tbody>
<tr>
<td>NORTH</td>
<td>1.809,0</td>
<td>1.931,7</td>
<td>1.988,3</td>
<td>2.110,8</td>
<td>2.333,1</td>
<td>2.577,0</td>
<td>2.850,9</td>
</tr>
<tr>
<td>NORTHEAST</td>
<td>3.095,8</td>
<td>3.263,5</td>
<td>3.332,2</td>
<td>3.356,6</td>
<td>3.544,3</td>
<td>3.821,3</td>
<td>3.962,6</td>
</tr>
<tr>
<td>MIDWEST</td>
<td>15.193,6</td>
<td>15.648,8</td>
<td>16.102,8</td>
<td>16.640,1</td>
<td>18.217,2</td>
<td>19.140,9</td>
<td>20.217,2</td>
</tr>
<tr>
<td>SOUTH-EAST</td>
<td>2.351,4</td>
<td>2.470,1</td>
<td>2.571,1</td>
<td>2.757,1</td>
<td>3.061,3</td>
<td>3.198,4</td>
<td>3.435,1</td>
</tr>
<tr>
<td>SOUTH</td>
<td>11.495,6</td>
<td>11.835,1</td>
<td>11.879,6</td>
<td>12.085,1</td>
<td>12.375,3</td>
<td>12.754,4</td>
<td>13.096,1</td>
</tr>
<tr>
<td>PR</td>
<td>5.249,6</td>
<td>5.464,8</td>
<td>5.437,5</td>
<td>5.502,7</td>
<td>5.623,8</td>
<td>5.668,8</td>
<td>5.810,5</td>
</tr>
<tr>
<td>SC</td>
<td>640,4</td>
<td>678,2</td>
<td>664,6</td>
<td>680,6</td>
<td>696,3</td>
<td>727,6</td>
<td>730,5</td>
</tr>
<tr>
<td>RS</td>
<td>5.569,6</td>
<td>5.692,1</td>
<td>5.777,5</td>
<td>5.901,8</td>
<td>6.055,2</td>
<td>6.358,0</td>
<td>6.555,1</td>
</tr>
<tr>
<td>BRAZIL</td>
<td>33.909,4</td>
<td>35.149,2</td>
<td>35.874,0</td>
<td>36.949,7</td>
<td>39.531,2</td>
<td>41.492,0</td>
<td>43.561,9</td>
</tr>
</tbody>
</table>

Key: (¹) Estimate as of April 2023.

Source: Adapted - CONAB/2023.

Table 3 shows the area planted in hectares in all regions of the country, with growth in all regions. Detailing the Southern region, the three states also have significant growth from the first crop (2016/17) to the last crop (2022/23). On average, Paraná had a planting area of 5.537 million hectares.

When making comparisons to various contexts, the State represents approximately 45.36% of the areas used in the cultivation of soybeans in relation to the southern region and, in comparison to Brazil, approximately 14.62%, pointing out how the state continues to be a major agricultural producer. With these percentages it is possible to verify that the areas are practically equal, with a small discrepancy in the period 2017/2018, and a minimal variation in relation to the average in the 2020/21 crop.

According to the State News Agency - AEN (2022), Paraná is the fourth largest economy in Brazil (it has 399 municipalities), achieved by Paraná in the consolidated data of 2020, and this result is the result of an organized growth that also came from these municipalities. The Paraná macro-regions are divided as shown in Figure 1.

Figure 1: Breakdown by Macro-Regions - PR.

The DERAL divides the state of Paraná into these 6 macro-regions, to accompany the agricultural production of the various crops in the state. The southern region is the largest and the central-west the smallest. Table 4, presents figures of soybean production in the last 6 crops, with a significant drop in the 2021/22 crop in practically all areas.
Soybean Production in the Municipality of Cascavel - PR: Rainfall Indices as the Main Influence Factor

Table 4 - Soybean production by PR Regions (in millions of tons).

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</thead>
<tbody>
<tr>
<td>MIDWEST</td>
<td>2.406,257</td>
<td>2.381,544</td>
<td>1.904,000</td>
<td>2.639,175</td>
<td>2.445,514</td>
<td>1.110,426</td>
<td>2.796,154</td>
</tr>
<tr>
<td>NORTHWEST</td>
<td>790.062</td>
<td>747.210</td>
<td>488.714</td>
<td>770.112</td>
<td>758.397</td>
<td>243.028</td>
<td>970.782</td>
</tr>
<tr>
<td>NORTH</td>
<td>5,421,634</td>
<td>5,227,125</td>
<td>4,282,881</td>
<td>4,954,584</td>
<td>5,017,600</td>
<td>3,432,773</td>
<td>5,535,186</td>
</tr>
<tr>
<td>SOUTHWEST</td>
<td>2,136,803</td>
<td>2,170,648</td>
<td>1,902,360</td>
<td>2,374,874</td>
<td>2,340,594</td>
<td>1,146,386</td>
<td>2,665,693</td>
</tr>
<tr>
<td>SOUTH</td>
<td>5,094,268</td>
<td>5,025,639</td>
<td>4,928,759</td>
<td>6,092,976</td>
<td>5,803,112</td>
<td>5,367,715</td>
<td>6,721,041</td>
</tr>
<tr>
<td>TOTAL</td>
<td>19.884,62</td>
<td>19,190,47</td>
<td>16,133,00</td>
<td>20,782,36</td>
<td>19,829,70</td>
<td>12,204,61</td>
<td>22,176,33</td>
</tr>
</tbody>
</table>


The 2021/22 crop had a drop in the western macro-region of 73.90% compared to the previous period, in contrast to the last period calculated the growth (estimate) is 285.66% growth. Still in the same period, the western region produced on average 924 kg of soybeans per hectare (15 bags of 60Kg per hectare). According to CONAB (2022), due to adverse weather conditions in the state between November and December, reflecting the phenomenon "La Niña", currently estimated a production of 13,050,4 thousand tons of soybeans in the 2021/22 Crop, a reduction of 34% compared to the previous Crop (19,880,1 thousand tons) 2020/21.

Numerous factors can intervene in the production of soybeans and other crops, and environmental conditions such as light, water, temperature and nutrients are the most influential in the productivity of a crop (TAGUS, 2019). Furthermore, the relationship between the amount of water in the soil present in the periods of the germination-emergence and the flowering-filling of grains is the most important. Soon after sowing, both the excess and the shortage of water can jeopardize the establishment of the plant stand. In this phase, the soybean needs to absorb 50% of its weight in water for germination to occur. However, if the amount of water is very high in the soil, a lack of oxygen can also reduce germination (EMBRAPA, 2009).

Soybeans, like the other summer crops in the state, are at an earlier stage in terms of phenology than in previous years, because of the adverse conditions of drought and high temperatures that speed up crop cycles. In the field, it can be seen that, as a result of these adverse climatic conditions, 64% of the areas are in a bad or regular situation, jeopardizing productivity and quality.

According to EMBRAPA (2023) from planting to harvesting "in Paraná, they are: early (up to 115 days); semi-early (116-125 days); medium (126-137 days) and semi-late (138-145 days)". Planting in the west begins around September, October with the end of the sanitary void with a harvest forecast in March, April the following year. In these periods, the man in the field depends a lot on the climate, mainly on the rainfall levels both in planting and in harvesting.

The municipality of Cascavel-PR is one of the largest cities of the western macro-region (territory), and also featured in grain production. According to IBGE (2023) the municipality has a territorial area of 2,091,199 km².

As a large grain producer, the municipality also has its economy dependent on agriculture, which also depends a lot on climatic conditions, in particular rainfall. The values are shown in Table 5 and were obtained through data mining, whose station capturing the indices is in the district of São João do Oeste, Paraná. The volumes from September to March, the soybean cycle, were used to determine the average.
Table 5 - Data on soybean production and average precipitation - Cascavel-PR.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Area (hectares)</th>
<th>Production (Tons)</th>
<th>Average Precipitation (mm)</th>
<th>Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>2022/23</td>
<td>531.420</td>
<td>2.033 213</td>
<td>167.9</td>
<td>3.826</td>
</tr>
<tr>
<td>2021/22</td>
<td>511.167</td>
<td>577.154</td>
<td>238.5</td>
<td>1.129</td>
</tr>
<tr>
<td>2020/21</td>
<td>520.190</td>
<td>1.878.406</td>
<td>158</td>
<td>3.611</td>
</tr>
<tr>
<td>2019/20</td>
<td>512.060</td>
<td>2.092.277</td>
<td>129</td>
<td>4.086</td>
</tr>
<tr>
<td>2018/19</td>
<td>529.993</td>
<td>1.538.569</td>
<td>138.4</td>
<td>2.903</td>
</tr>
<tr>
<td>2017/18</td>
<td>569.450</td>
<td>1.930.435</td>
<td>162.3</td>
<td>3.390</td>
</tr>
<tr>
<td>2016/17</td>
<td>557.645</td>
<td>2.192.583</td>
<td>243.9</td>
<td>3.932</td>
</tr>
</tbody>
</table>


Table 5 will be discussed in the next section (in detail), since the Sisvar software was used to check whether there are any relationships between the variables (area, production and precipitation).

5 RESULTS AND DISCUSSION

For the analyzes (Table 5), the software Sisvar (FERREIRA, 2008) was used, in which inferences were made between the variables area (in hectares), production (tons) and precipitation (average rainfall, and mm in the period of the soybean cycle). For these, the Tukey test was applied with 5% significance, indicating that in both parameters "p value" lower than significance; which demonstrates that there are both rainfall indices and cultivated area influence in the final production of soybeans.

The tests were conducted related to the last summer harvest and presented in Table 6. For the statistical analyzes, data were mined in the DERAL and IAT, concerning the municipality of Cascavel-PR. These minerations are shown in Tables 5.

Table 6 - Tukey test at 5% significance: Production, rainfall and soybean planting area in Cascavel-PR

<table>
<thead>
<tr>
<th>YEAR</th>
<th>PRODUCTION (tons)</th>
<th>AVERAGE PRECIPITATION (mm)</th>
<th>AREA (hectares)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2021/22</td>
<td>577.2</td>
<td>162.3 A1</td>
<td>511.2 B1</td>
</tr>
<tr>
<td>2018/19</td>
<td>1538.6</td>
<td>158.0 A2</td>
<td>530.0 B2</td>
</tr>
<tr>
<td>2020/21</td>
<td>1878.4</td>
<td>138.5 A3</td>
<td>520.2 B3</td>
</tr>
<tr>
<td>2017/18</td>
<td>1930.4</td>
<td>238.5 A4</td>
<td>569.5 B4</td>
</tr>
<tr>
<td>2022/23</td>
<td>2033.2</td>
<td>243.9 A5</td>
<td>531.4 B5</td>
</tr>
<tr>
<td>2019/20</td>
<td>2092.3</td>
<td>129.0 TO 6</td>
<td>512.1 B6</td>
</tr>
<tr>
<td>2016/17</td>
<td>2192.6</td>
<td>167.9 TO 7</td>
<td>557.6 B7</td>
</tr>
</tbody>
</table>

Source: Self-authored.

It can be observed that there were differences between the variables (P<=0.05), according to Table 6, indicating that the planting area and precipitation interfere in production. Although the rainfall rates were variable, October 2021, were recorded about 447 mm, and in the months of November and December were far below this volume (respectively 68mm and 37mm), which may have a direct relationship with the production in that year. According to Agrosmart (2019), soybean cultivation requires an average of 7 mm of water per day, totaling between 450 mm and 800 mm throughout the cycle. In all the harvests analyzed the indices were higher than these averages, pointing to rainfall irregularities as a reason for the fall in production, in particular the 2021/22 crop that had only 577.2 tons of soybeans produced.

The climate factor, ends up being the biggest challenge of the farmers, especially in the southern region, with climatic oscillations, irregularities in the rains. The rainfall has a major influence on soybean production, which is a crop that is extremely sensitive to climatic
conditions. Excess or lack of rain can affect the development of the plant, jeopardizing the yield of the harvest.

During the planting period, which occurs between September and December, it is important that there is sufficient moisture in the soil for the seeds to germinate and the plants to develop. However, excessive rainfall can cause soil soaking, impairing root oxygenation and increasing the risk of disease.

However, during the period of growth and flowering, which occurs between January and March, soybeans need regular rainfall to maintain good development and to avoid hydric stress, which can lead to the fall of flowers and consequently to a reduction in the formation of pods and seeds.

Between March and May, it is important that rainfall is reduced so that pods and seeds are well dried, preventing disease and reducing quality loss. Therefore, rainfall is fundamental for soybean production and must be constantly monitored by producers to ensure a satisfactory harvest.

The adoption of sustainable land and crop management practices, coupled with the use of efficient technologies, can help reduce climate impacts on soybean plantations and increase productivity in a more sustainable way (PEREDA, 2023).

As encouragement to the farmers of the state, the AEN (2023), pointed out that Paraná will produce 22.37 million tons of soybeans (crop 2022/23, forecast), thus being the largest crop of soybeans in history in the state. This volume represents 15% of the national harvest, and an increase of 83% compared to the 2021/2022 harvest. Soybean production has fluctuated in the last few harvests, due to climatic oscillations, but even so the areas planted with soybeans have been increasing over the years, as shown alternating in the last few harvests. The areas especially of soybeans have been growing as shown in Table 3. Still, according to AEN (2023) the state has been standing out and maintaining the second position in the national production of commodity.

Now, it is clear that Brazil and its agricultural potential will continue to supply the various markets with countless inputs, especially the soybean that is essential in the production of oils and in the composition of animal breeds and in human nutrition.

For Neves et al. (2023), the agribusiness sector has its results optimized by virtue of the technologies inserted in its productive chain. Sustainability plays a key role in the advancement of business; in this context, a paradigm shift in productive processes is observed, characterized by a continuous search for the preservation and restoration of ecosystems, in line with the aspirations of future generations for a better quality of life.

6 FINAL CONSIDERATIONS

In conclusion, the production of the west of Paraná, is an activity of great economic importance for the region and for the country as a whole. However, soybean production is highly influenced by climatic conditions, which can affect crop productivity and quality. Extreme weather conditions, such as excessive rainfall or prolonged droughts, pose a challenge for soybean producers.

Therefore, it is essential that sustainable agricultural practices are adopted that can minimize the effects of climatic variations, such as the use of soybean varieties adapted to local conditions, proper soil management, conservation of water resources and the use of cultivation techniques that take into account the characteristics of the regional climate.

Furthermore, investments in research and technological innovation are indispensable for the advance of soybean production in the region, allowing for the identification of varieties that are more resistant to climate changes and the development of more efficient and sustainable techniques for managing the crop. Sustainable production measures can ensure profitable
agricultural activity while preserving the environment and the natural resources of the region, contributing to the economic and social development of the local community.

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