Embrapa
Portal de Periódicos da Embrapa
International Journal of Maize & Sorghum
Formerly Revista Brasileira de Milho e Sorgo
ABMS

ISSN 3086-5433

PERFORMANCE OF MAIZE VARIETIES AND HYBRIDS IN SANTA CATARINA, BRAZIL

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ABSTRACT – The imbalance between maize consumption and production in Santa Catarina results in a deficit that, in some years, exceeds 5 million tons. This scenario is already considered one of the greatest challenges to the competitiveness of agriculture and agroindustry in the state. The objective of this study is to compare the grain productivity of open-pollinated varieties (OPVs) and simple maize hybrids across three regions of Santa Catarina. The research was carried out in the West, North Plateau, and Itajaí Valley regions during the 2021/22, 2022/23, and 2023/24 growing seasons, considering first-season maize cultivation, predominantly under rainfed conditions, with supplementary irrigation in Ituporanga (Itajaí Valley) and at Cepaf in Chapecó (Western region). Four maize cultivars (treatments) were used. The SCS155 Catarina and Composto B cultivars consist of OPVs developed by Epagri, and the simple hybrid cultivars Pioneer P3016 and Syngenta Feroz. The experiment followed a randomized block design, with four replicates per location, yielding 16 plots per location and 48 plots in total. Grain yield (kg ha^{-1}) data were subjected to analysis of variance (ANOVA), and means were compared using Tukey's test ($p \leq 0.05$). In most environments and growing seasons, no significant yield differences were observed between OPVs and hybrids. These results indicate that OPVs can be a viable alternative for maize production under rainfed conditions, by reducing seed costs and improving economic stability in family farming systems.

Keywords: *Zea mays,* production cost, farm income, water deficit.

Maize is a key energy source for swine, poultry, and dairy production chains in Santa Catarina, Brazil. However, the area devoted to maize cultivation in the state has declined over recent years, compromising the supply required to sustain animal production systems. This reduction is largely associated with the expansion of soybean cultivation, which farmers often perceive as a more economically attractive option (Elias et al., 2019; Giehl et al., 2022). Consequently, the gap between maize consumption and production has widened, exceeding five million tons in some years and becoming a critical constraint to the competitiveness of the state's agricultural and agro-industrial sectors (Estado […], 2021).

Maize production in Santa Catarina is largely carried out by family farmers, who typically operate under rainfed conditions and with limited access to irrigation infrastructure. As a result, crop performance is highly vulnerable to climatic variability, particularly water deficits during key developmental stages (Sanches et al., 2019; Ripplinger et al., 2020). Under such conditions, high-yield hybrid maize cultivars may not always be the most practical choice. Indeed, single-cross hybrid seeds can cost up to five times as much as open-pollinated variety (OPV) seeds (Bermudez et al., 2016; Pereira Filho & Borghi, 2020), raising questions about their cost-effectiveness for small-scale farmers facing environmental and financial constraints.

Therefore, this study aimed to compare the grain yield of open-pollinated varieties and single-cross hybrids of maize, cultivated under rainfed conditions across three regions of Santa Catarina over three consecutive growing seasons.

Materials and Methods

This study was conducted in three locations across the state of Santa Catarina, Brazil, representing the Western, Northern Plateau, and Itajaí Valley regions. In Chapecó (Western region), trials were carried out during the 2021/22 and 2022/23 growing seasons at the experimental area of the Federal University of Fronteira Sul (UFFS), and during the 2023/24 season at the Center for Research on Family Agriculture (Cepaf), part of the Agricultural Research and Rural Extension Company of Santa Catarina (Epagri). Trials in Papanduva (Northern Plateau) and Ituporanga (Itajaí Valley) were also conducted at experimental stations operated by Epagri.

Four maize cultivars were evaluated as treatments. Two were open-pollinated varieties (OPVs) developed by Epagri: SCS155 Catarina and Composto B[1]. The other two were single-cross hybrids: Pioneer P3016 and Syngenta Feroz. All cultivars were dual-purpose, suitable for both grain and silage production.

The experiment followed a randomized complete block design (RCBD) with four replicates, totaling 16 plots per location and 48 plots overall. Sowing was performed manually between October and November over three consecutive growing seasons. No prior soil tillage was conducted. Seeds were sown at a depth of 5

[1]Cultivar registered as SCS157 Prodígio in the National Cultivar Registry under nº 54925, and protected in the National Cultivar Protection System under Protection Certificate nº 20250073.

cm in furrows opened using a subsoiler pulled by a tractor. Sowing dates were as follows:

- Chapecó: November 8, 2021; November 9, 2022; and October 10, 2023
- Papanduva: November 9, 2021; October 5, 2022; and October 3, 2023
- Ituporanga: November 4, 2021; October 27, 2022; and October 26, 2023

In Chapecó, plots measured 5.5 meters in length by 6.4 meters in width (41.6 m²), with an additional 1-meter corridor between plots. In Papanduva and Ituporanga, plots were 5 meters long by 3.2 meters wide. Plant density was standardized at 62,500 plants per hectare (spacing: 0.80 m × 0.20 m) across all sites. Pest and disease control was carried out chemically and uniformly across all cultivars, with interventions tailored only to specific pests or diseases occurring in each location and season.

Fertilization was based on soil analysis results and the recommendations outlined in the Fertilization and Liming Manual for the States of Rio Grande do Sul and Santa Catarina, targeting an expected grain yield of 9,000 kg ha^{-1}.

- In Chapecó, 650 kg ha^{-1} of a 9:33:12 NPK fertilizer was applied in the planting row, followed by a topdressing of 150 kg ha^{-1} of urea and 75 kg ha^{-1} of potassium chloride 30 days after sowing.
- In Papanduva, 400 kg ha^{-1} of the same fertilizer was applied in the row, with 175 kg ha^{-1} of urea topdressed 30 days after sowing.
- In Ituporanga, only 300 kg ha^{-1} of urea was applied as topdressing 30 days after sowing, because the area already has adequate soil fertility.

All trials were conducted under rainfed conditions, without irrigation.

Grain yield (kg ha^{-1}) was determined by manually harvesting the two central rows of each plot. Yields were adjusted based on the effective harvested area, and grain moisture content was standardized to 13%.

The yield data were analyzed using Analysis of Variance (ANOVA), followed by Tukey's test at a 5% significance level, with statistical analysis performed in R version 4.4.1.

Although grain yield was the primary variable evaluated in this study, other important yield components, such as the number of ears per plant and thousand-grain weight, were not assessed. These variables are directly related to yield formation and may contribute to a better understanding of the performance of different cultivars under contrasting environmental conditions (Sangoi et al., 2006; Taiz et al., 2017). The inclusion of these components in future studies could provide additional insights into the physiological and agronomic responses of open-pollinated varieties and hybrids, particularly under water-limited conditions.

Results and Discussion

Analysis of variance (ANOVA) revealed no statistically significant differences in grain yield among the four maize cultivars evaluated in

Chapecó across all three growing seasons (Figure 1A). In Papanduva, hybrids outperformed open-pollinated varieties (OPVs) only in the 2023/24 season (Figure 1B). In Ituporanga, the hybrid P3016 showed higher productivity than the OPVs solely in the 2021/22 season. In 2022/23, no statistical differences were observed between hybrids and OPVs. Notably, in the 2023/24 season, both the OPV SCS155 Catarina and the hybrid Feroz yielded significantly more grain than the other tested genotypes (Figure 1C). Similar findings were reported by Sangoi et al. (2006), who observed yields comparable to those of OPVs and hybrids (single and double) under low-input management conditions in trials conducted in Rio Grande do Sul and Santa Catarina.

From an economic perspective, the lack of significant differences in grain yield across most environments underscores the importance of considering cost–benefit trade-offs when selecting cultivars. Hybrid seeds can cost substantially more than OPVs (Pereira Filho & Borghi, 2020), increasing the financial investment required for crop establishment. Under rainfed conditions, where yield is strongly influenced by climatic variability, higher input costs may not yield proportional gains. In this context, OPVs may represent a more economically viable alternative, particularly for smallholder farmers operating under resource-limited conditions.

In addition, differences in the efficiency of input use should be taken into account. OPVs are often better adapted to low-input systems, maintaining satisfactory performance even under reduced fertilization and limited technological investment (Sangoi et al., 2006). On the other hand, hybrids generally require more favorable management conditions to express their full productive potential (Tollenaar & Lee, 2002). These findings highlight the importance of aligning cultivar choice with the production system and available resources.

Results across different environments suggest that open-pollinated varieties (OPVs) may exhibit greater yield stability under variable environmental conditions. While hybrids are generally developed to maximize yield under favorable conditions, their performance may be more affected by environmental stresses such as water deficit or excess rainfall (Tollenaar & Lee, 2002). In contrast, OPVs tend to have a broader genetic base, which may contribute to greater adaptability and more stable performance across contrasting growing conditions (Ceccarelli, 1996).

During the 2021/22 season, average grain yield in Chapecó did not exceed 1,500 kg ha^{-1}—substantially lower than the statewide average of 5,632 kg ha^{-1} for the same season (Giehl et al., 2022). This low productivity can be attributed to the lack of rainfall, which adversely affected both maize OPVs and hybrids (Figure 2). By January 2022, yield losses due to drought stress in Santa Catarina were estimated at 43%, ranging from 20% to 80% across microregions. The most affected areas were the West and Northern Plateau regions (Giehl et al., 2022).

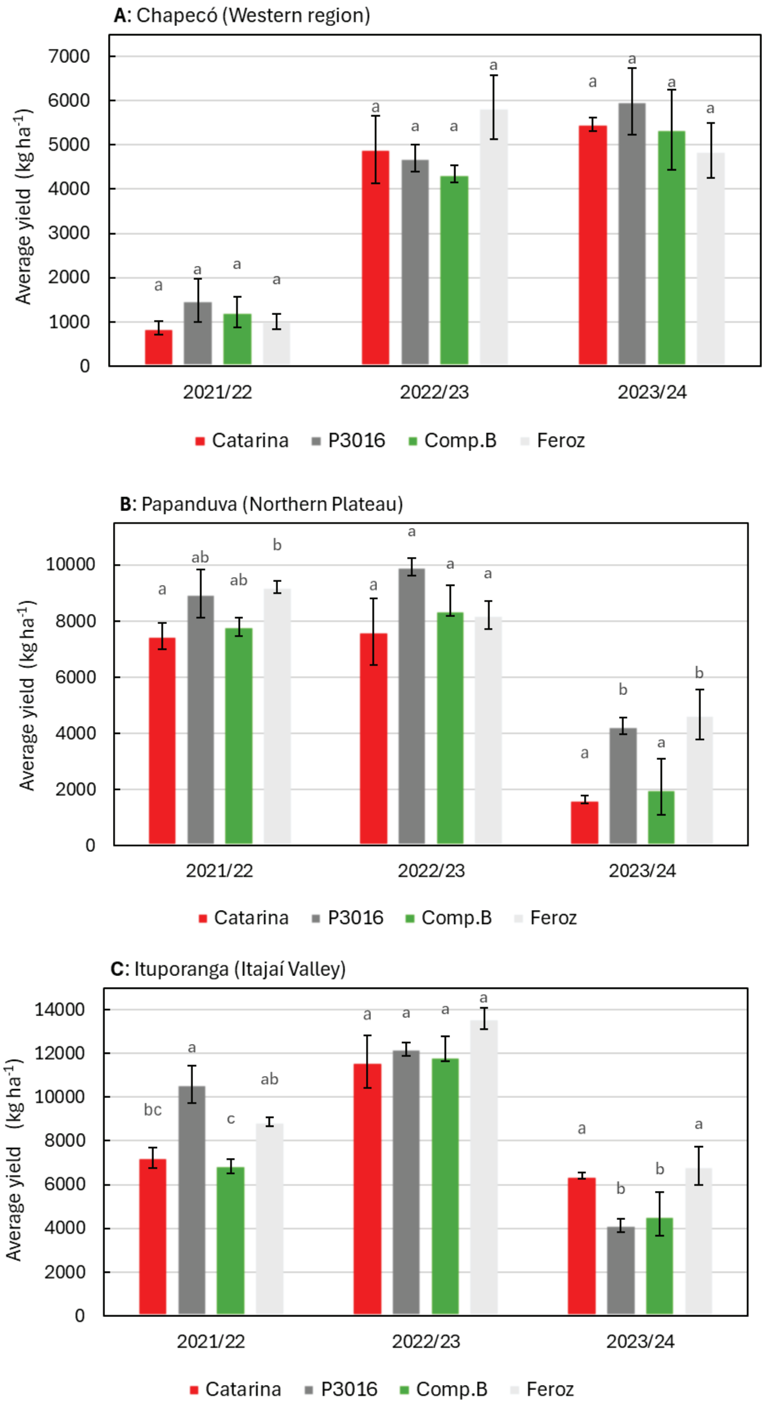

Figure 1. Average maize grain yield in the 2021/22, 2022/23 and 2023/24 harvests for the cultivars Catarina and Composto B (OPVs), P3016, and Feroz (simple hybrids), in Chapecó (A), Papanduva (B), and Ituporanga (C). Note: Error bars represent the standard deviation. Letters represent the Tukey test at the 5% significance level.

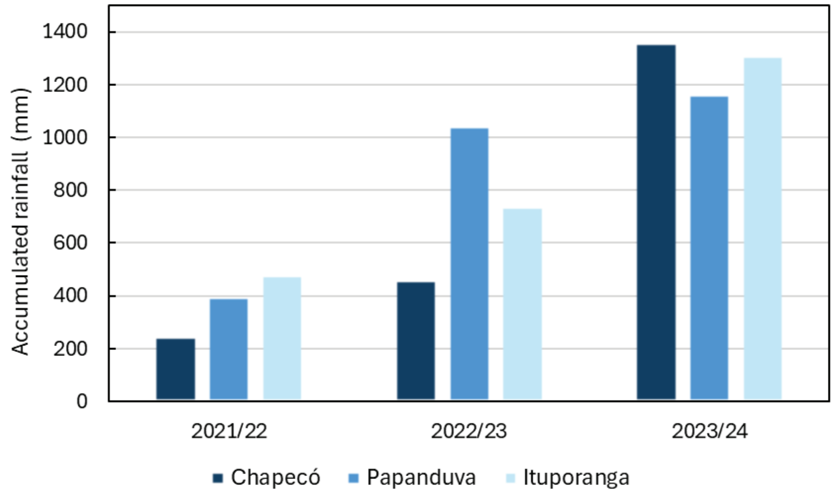

Figure 2. Accumulated rainfall during the maize development period (from sowing to physiological maturity) in the 2021/22, 2022/23, and 2023/24 harvests, in trials conducted in Chapecó, Papanduva, and Ituporanga.

Rainfall records in Chapecó between November 2021 and March 2022—coinciding with the maize growth cycle—showed extended periods without significant precipitation (>5 mm), totaling just 245 mm (Figure 2). In contrast, Papanduva and Ituporanga received greater rainfall during the same season, resulting in higher yields for the maize cultivars tested there.

The 2022/23 growing season presented more favorable rainfall conditions, especially in Ituporanga, where grain yields exceeded 12,000 kg ha^{-1} (Figure 1B). However, the 2023/24 season was marked by episodes of intense rainfall (>100 mm day^{-1}), which reduced grain yields in Papanduva and Ituporanga. In these locations, trial plots are more prone to waterlogging due to limited soil drainage.

The results obtained across the different growing seasons highlight the strong influence of climatic conditions on maize grain yield in the evaluated regions. Periods of water deficit, as observed in the 2021/22 season, and episodes of excessive rainfall, such as those recorded in the 2023/24 season, negatively affected crop performance. These conditions can limit maize development by reducing water availability or causing soil waterlogging, which impairs root activity, nutrient uptake, and grain filling (Taiz et al., 2017). In this context, the performance observed among cultivars reinforces the importance of selecting genotypes with greater adaptability to environmental variation.

Choosing between OPVs and hybrids should not be based only on grain yield potential, but also on the production conditions in which the crop is established. In environments with greater climatic variability and under rainfed conditions, where yield is more uncertain, the use of lower-cost technologies becomes an important strategy to reduce production risks. In this context, OPVs represent a viable alternative, as they combine lower seed costs with stable performance across different growing conditions.

Conclusions

In Chapecó, grain yields of OPVs did not differ significantly from those of hybrids. Similar results were observed in the other two regions, apart from the 2021/22 season in Ituporanga and the 2023/24 season in Papanduva, where hybrids demonstrated superior performance.

Overall, the OPVs tested proved competitive under the evaluated conditions, particularly during growing seasons with greater climatic variability and in production systems with lower input use. Under these conditions, OPVs can serve as a strategy to reduce production costs (with seeds) and contribute to the economic viability of maize production, especially for smallholder farmers.

Acknowledgments

This research was funded by the Research and Innovation Support Foundation of the State of Santa Catarina (FAPESC).

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