

AGRONOMIC PERFORMANCE AND ECONOMIC VIABILITY OF MAIZE CULTIVARS OF OPEN POLLINATION

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ABSTRACT - The open pollination cultivars (VPA) of maize are an alternative of production for a small property, because it presents a good agronomic performance and low production cost, mainly due to the possibility of seed production with low cost. The objective of this research was to evaluate the agronomic performance and economic viability of open pollination cultivars of maize in a low-altitude site in the central region of the state of Rio Grande do Sul. The experiment was conducted during the 2018/2019 crop season, in the experimental area of the Federal University of Santa Maria-UFSM, in the municipality of Santa Maria-RS. The open pollination maize cultivars (SCS 154 Fortuna, SCS 155 Catarina, and SCS 156 Colorado) were used. The experiment consisted of three treatments and four replicates and the experimental design used was that of complete blocks at random. The open pollination cultivars presented an adequate agronomic performance in a low-altitude region in the state of Rio Grande do Sul, associated with the economic viability of the crop in the central region of the state.

Keywords: VPA maize cultivars, grain yield, production cost.

DESEMPENHO AGRONÔMICO E VIABILIDADE ECONÔMICA DE CULTIVARES DE MILHO DE POLINIZAÇÃO ABERTA

RESUMO - As cultivares de polinização aberta (VPA) de milho, são uma alternativa de produção para pequena propriedade, pois apresenta bom desempenho agrônômico e baixo custo produção, principalmente pela possibilidade de produção de sementes com baixo custo. O objetivo do trabalho foi avaliar o desempenho agrônômico e a viabilidade econômica de cultivares de polinização aberta de milho em local de baixa altitude na região central do estado do Rio Grande do Sul. O experimento foi conduzido durante a safra agrícola de 2018/2019, na área experimental da Universidade Federal de Santa Maria-UFSM, no município de Santa Maria-RS. Foram utilizadas as cultivares de milho de polinização aberta (SCS 154 Fortuna, SCS 155 Catarina e SCS 156 Colorado). O experimento foi composto por três tratamentos e quatro repetições e o delineamento experimental utilizado foi blocos completos ao acaso. As cultivares de polinização aberta apresentaram adequado desempenho agrônômico em região de baixa altitude no estado do Rio Grande do Sul, associado a viabilidade econômica do cultivo na região central do estado.

Palavras-chave: cultivares de milho VPA, produtividade de grãos, custo de produção.

INTRODUCTION

Maize (*Zea mays* L.) is among the agricultural species with the largest area of cultivation, due to the great nutritional value of the grain and the high adaptability of the crop to different environments. Mainly provided by the high genetic variability of the species found mostly in varieties and cultivars of open pollination, serving as the basis for genetic improvement in the creation of new cultivars (LANGNER et al., 2019). Besides being used as germplasm to improve the nutritional quality of new maize cultivars (LIM and YI, 2019). The cultivars/varieties of open pollination (VPA) of maize, is of great importance for family agriculture, because it has a low cost of implantation and maintenance, and there is the possibility of seeds being produced by the producers themselves, a fact that adds relevant social importance (ROCHA et al., 2018).

VPA maize cultivars are characterized by great variability in grain yield and yield components (BALBINOT et al., 2005). Even with high variability among VPA maize cultivars, they may present similar agronomic performance to hybrid maize cultivars, especially when low soil fertilization occurs, showing an alternative option of income and food production for the family farmer (BIANCHETTO et al., 2017)

Over the years, more and more seeks to increase maize yield, regardless of the region of cultivation, with practices and use of technologies such as correction and proper fertilization of the soil, adoption of the no-tillage system, integrated management of invasive plants, diseases, and pests, as well as the adoption of seeds of higher genetic quality, such as hybrids (EICHOLZ et al., 2016).

However, this will affect increasing the cost of production when this substitution of traditional VPA cultivars occurs, by hybrid cultivars with greater productive potential,

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but which require more technology to express their potential and higher cost of seed acquisition, becoming inaccessible to many farmers who practice family farming (BIANCHETTO et al., 2017). That is, many producers in small farms have difficulties in accessing basic inputs for soil correction and irrigation use, which decreases the possibility in the economic return of hybrid cultivars with a high cost of seed acquisition.

Sangoi et al. (2006) state that the adequacy of the characteristics of cultivars with the management system is important to increase the technical and economic efficiency of corn production in southern Brazil. Due to the importance of this fact and maize in the small property, studying the viability of the crop and the positioning of VPA cultivars is of considerable applicability to the family producers of the central region of the state of Rio Grande do Sul, as it is an alternative of low-cost production and productivity that guarantee the maintenance of the property.

VPA maize cultivars launched in breeding programs in Santa Catarina and with good acceptance in small family properties were not studied under low altitude conditions in the state of Rio Grande do Sul. Because of the aspects observed, the objective of this study was to evaluate the agronomic performance and economic viability of open pollination cultivars of maize in a low-altitude location in the central region of the state of Rio Grande do Sul.

MATERIALS AND METHODS

The experiment was conducted during the 2018/2019 crop season, in the experimental area of the Research Group on Ecophysiology and Annual Crop Management (GEMCA) of the Federal University of Santa Maria-UFSM, in the municipality of Santa Maria, in the central region of the State of Rio Grande do Sul, located at latitude 29° 71' S, longitude 53° 70' W, with an altitude of 90 m. The site of the experiment has soil classified as Arenic Dystrophic Red Argisol (SANTOS et al., 2018) and the climate according to the Köppen classification is classified as *Cfa*, characterized as humid subtropical climate, with hot summers and no dry season defined throughout the year (ALVARES et al., 2013).

The sowing of the experiment occurred on September 13, 2018, adopting the no-tillage system. Open pollination cultivars (SCS 154 Fortuna, SCS 155 Catarina, and SCS 156 Colorado) were used. The sowing density used was 2.7 seeds per linear meter, intending to reach a population of 60.000 plants ha⁻¹. The experiment consisted of three treatments and four replications, and the experimental design of complete randomized blocks was adopted (STORCK et al., 2016).

The plots consisted of 5 lines with spacing between lines of 0.45 m and 5 m in length, totaling 11.25 m² of the plot area. For the evaluations, the three central lines were considered, eliminating 1 row of each lateral and 0.5 m from the ends of the lines, establishing a useful area of the plot of 5.4 m². The base fertilization was 400 kg ha⁻¹ of the NPK elements of the commercial formula 5-20-20, providing 20 kg ha⁻¹ of N, 80 kg ha⁻¹ of P₂O₅, and 80 kg ha⁻¹ of K₂O.

Subsequently, cover fertilization was performed with urea (45% of N) at a dose of 150 kg ha⁻¹. The added N was divided into two applications, 50 % in each application in the vegetative stages V3 and V5 (when the plants had three and five expanded leaves respectively). During the development of the crop, the cultural treatments carried out in the experiment followed the technical indications for maize crop for the state of Rio Grande do Sul (RTAPM, 2017).

ED-VT (emergency days to VT stage) was carried out in the field; ED-R1 (emergency days to stage R1) and ED-R6 (emergency days to stage R6), according to phenological scale (FANCELLI, 1986). Subsequently, when the plants reached physiological maturation, 10 cobs per plot were collected, randomly chosen to evaluate the yield components of the crop. The evaluations were: CW (weight of the cob), NR (number of rows), NGR (number of grains per row), CL (cob length), CD (cob diameter), CCD (corn cob diameter), CCW (corn cob weight), GW (grain weight), TGW (weight of a thousand grains).

After the evaluations, the weight of the 10 cobs was added to the grain weight of the plot to determine the GY (grain yield), the harvest was carried out on January 22 and 23, 2019. The data were submitted to variance analysis and the means were compared by the Scott-Knott test, with a 5% probability of error. The analyses were carried out with the help of the statistical program SISVAR (FERREIRA, 2011).

RESULTS AND DISCUSSION

The phenological variables ED-VT, ED-R1, and ED-R6 differed significantly among the maize cultivars VPA, providing the formation of groups of distinct means (Table 1). The varieties SCS 155 Catarina and SCS 156 Colorado obtained the highest means of ED-VT, required 65.75 days to enter the bolting stage (VT), for the variable ED-R1, the formation of two groups of means occurred, where one group was composed of the cultivar SCS 155 Catarina and group 2 by the varieties SCS 154 Fortuna and SCS 156 Colorado, presented a smaller number of days to enter the reproductive stage R1.

The cultivar SCS 156 Colorado stood out as the earliest cultivar in this experiment, requiring 105 days from emergence to stage R6 (ED-R6), at which time the plant ceases the translocation of nutrients and water to the grains, called physiological maturation. The cultivar SCS 155 Catarina presented the longest cycle with 110.75 days to achieve physiological maturation. The cycle differences between cultivars are important for farmers because by adopting more than one cultivar with different cycles, they reduce the risk of productivity losses due to lack of water. Higher values of ED-VT were found with the same varieties, where the cultivar SCS 155 Catarina needed 73 days until flowering in a study conducted by (PATZLAFF et al., 2020).

The duration of the phenological phases and the cycle in days are associated with variations in environmental conditions, temperature is the most important climatic element to predict the phenological

events of the crop, as long as there is no water deficiency (GADIOLI et al., 2000). Knowledge of plant phenology is indispensable in several aspects, in studies and applications involving climate-plant interactions, such as

agroclimatic zoning, sowing calendars, crop monitoring, evaluation of climatic risks, besides determining factor for irrigation (BERGAMASCHI and MATZENAUER, 2014).

TABLE 1 - Phenology of VPA maize cultivars. Average emergency days to VT stage (ED-VT), emergency days to stage R1 (ED-R1) and emergency days to stage R6 (ED-R6).

Treatments	ED-VT (days)	ED-R1 (days)	ED-R6 (days)
SCS 154 Fortuna	64.75 b*	68.25 b	107.75 b
SCS 155 Catarina	65.75 a	70.50 a	110.75 a
SCS 156 Colorado	65.75 a	67.00 b	105.00 c
Average	65.42	68.58	107.83
CV (%)	0.72	1.77	0.6

*Means followed by the same letter in the column do not differ significantly by the Scott-Knott test, at the significance level of 5% error.

The analysis of means for the yield components CW, NR, NGR, CL, CCW, GW, and GY did not present statistically significant differences between treatments (Table 2). Bianchetto et al. (2017) found an average cob weight of 140 g, a value lower than that found in this study, which reached an average of 202.96 g among cultivars. The number of rows and the number of grains per row were similar to those found by Balbinot et al.

(2005), the author also points out that the number of grains per row is an important component in predicting grain yield in varieties of open corn pollination. In addition to the genetic potential, the good agronomic performance of the experiment is also conditioned on adequate cultural management, and the good water availability present during the cultivation period of the experiment.

TABLE 2 - Averages of the yield components: cob weight (CW, in g), number of rows (NR), number of grains per row (NGR), cob length (CL, in cm), cob diameter (CD, in cm), corncob diameter (CCD, in cm), corncob weight (CCW, in g), grain weight (GW, in g), the weight of a thousand grains (TGW, in g) and grain yield (GY, in kg ha⁻¹).

Treatments	CW	NR	NGR	CL	CD
SCS 154 Fortuna	202.62 a*	14.65 a	32.15 a	17.90 a	4.82 b
SCS 155 Catarina	207.90 a	14.20 a	30.40 a	17.33 a	5.03 a
SCS 156 Colorado	198.35 a	14.70 a	32.75 a	17.10 a	4.77 b
Average	202.96	14.52	31.76	17.44	4.87
CV (%)	7.70	3.93	5.07	4.35	1.70
Treatments	CCD	CCW	GW	TGW	GY
SCS 154 Fortuna	3.02 a	36.05 a	166.57 a	340.20 b	9133.45 a
SCS 155 Catarina	3.12 a	37.77 a	170.12 a	385.75 a	9515.95 a
SCS 156 Colorado	2.86 b	32.25 a	166.10 a	328.75 b	8636.22 a
Average	2.99	35.36	167.60	351.56	9095.21
CV (%)	2.45	7.46	8.46	6.13	11.29

*Means followed by the same letter do not differ significantly by the Scoot-Knott test, at the significance level of 5% error.

The CCW character is important, being negatively associated with productive efficiency, because the plant spends photoassimilates for the formation of a non-productive structure that causes reduction of the space destined to the arrangement and lower grain depth (CARVALHO et al., 2014), besides affecting the weight of grains, which is related to productivity. Concerning the CL character. Patzlaff et al. (2020) also found no significant differences for cob length, in a study conducted with the same cultivars VPA, but obtained higher means.

For grain yield, an average of 9.095.21 kg ha⁻¹ was observed, higher than the average yield of Rio Grande do Sul for the 2018/2019 crop, which was 7.562 kg ha⁻¹ (CONAB, 2019). Productivity also higher than those observed by author Bianchetto et al. (2017), which reached 6.439 kg ha⁻¹ in his research that evaluated the agronomic performance of VPA maize at different fertilization levels

and also higher than the research of Balbinot et al. (2005) who obtained average productivity of 5.371 kg ha⁻¹ in his study of the contribution of yield components in grain yield in varieties of open corn pollination.

The productivity results obtained in this study contribute with those verified by Emygdio et al. (2011), that obtained averages greater than 7.600 kg ha⁻¹ and Saraiva et al. (2019) in its study of agronomic performance of varieties of crioules corns cultivated in Vale do Jequitinhonha got productivity 7.063 kg ha⁻¹. The results of this study indicate the high potential of grain yield and adaptation of cultivars to the central region of the state of Rio Grande do Sul because even because the cultivars are developed in Santa Catarina, they presented a yield of 1.533 kg ha⁻¹ higher than the average productivity of the state of Rio Grande do Sul.

The characters CD, CCD, and TGW showed a significant difference between the treatments so that two groups of means for both variables were formation. The cultivar SCS Catarina obtained the highest mean of ED (5.03 cm), CCD (3.12 cm), and TGW (385.75 g) (Table 2). The cob diameter is associated with cob weight, which is the main character to be considered, however, the cob diameter is negatively correlated with the cob weight (OLIVEIRA et al., 1987).

The results observed in this study to the weight of 1,000 grains contribute to the results found in the study by Ohland et al. (2005), which evaluated soil cover crops and nitrogen fertilization in maize under no-tillage and

obtained average weight values of 1,000 similar grains, yet the author states that the weight of 1,000 grains is a characteristic influenced by genotype, nutrient availability and climatic conditions during grain filling stages.

When comparing the average cost of maize production in the state of Rio Grande do Sul, for crops with the high and low level of technological investment, according to data taken from the National Supply Company-Conab, for the 2018/2019 crop, it is verified that the production costs of a crop with a low investment level are 45 % lower than the cost of a crop with a high level of investment (CONAB, 2018) (Table 3).

TABLE 3 - The average cost of maize production in the stage of Rio Grande do Sul for crops with high level and low level of technological investment, according to data from the National Supply Company-Conab, for the 2018/2019 harvest.

Cost type	Cost item	Production cost (R\$ ha ⁻¹)	
		High investment	Low investment
Crop costing	Administrator	134.12	197.50
Crop costing	Pesticides	243.44	248.29
Crop costing	Soil analysis	2.20	2.10
Crop costing	Fertilizers	907.50	493.75
Crop costing	Labour	19.32	4.73
Crop costing	Seeds	592.00	0.00
Crop costing	Tractors and harvesters	240.17	196.12
Financial expenses	Financing interest	88.31	73.61
Other expenses	Technical assistance	42.78	31.51
Other expenses	Cessr ¹	64.69	54.33
Other expenses	Administrative	64.16	47.27
Other expenses	Storage	206.33	132.21
Other expenses	External transport	153.75	98.40
Total cost (R\$)		3052.34	1663.22

¹Cessr-special contribution for the rural social security. *Data with drawn and adapted from the National Supply Company - Conab 2018.

Given the average price of the 60 kg per bag of maize paid to the producer during the period in which the experiment was harvested of R\$ 32.00 for the municipality of Santa Maria-RS (EMATER, 2019), the production system that uses high technology for maize production, would have a production cost equivalent to 95.38 sc ha⁻¹ and the system with the low technological level the cost of 51.97 sc ha⁻¹. The difference in production cost is due to the reduction in fertilizer costs and especially with the elimination of seed purchase expenses, which in the system with a high technological level where hybrid seeds are used the average seed cost is 18.5 sc ha⁻¹. According to the average productivity of the experiment reducing production costs to the low technological level (Table 3), the rural producer would obtain a net income of R\$ 3187.74 ha⁻¹, highlighting that this year, the climatic conditions were favorable for the cultivation of maize. In the low technological level system, the use of VPA cultivars enables the farmer to produce his seed, thus reducing production costs.

Considering that the southern region of the country, especially the state of Rio Grande do Sul, which includes a large number of family producers in Brazil, cultivars with a low cost for seed acquisition can be a good

alternative of cultivation and source of income (MACHADO and FONTANELI, 2014). There are numerous factors, such as low seed cost, greater plasticity under stress conditions, and the possibility of own seed production, placing open pollination maize cultivars as a cultivation option for farmers on a small property, usually with little capital and low technology (EMYGDIO and PEREIRA, 2006).

In addition, the use of VPA cultivars is that the use of cultivars adapted to the region of cultivation may present similar agronomic performance to hybrid maize cultivars (BALBINOT et al., 2005). As variedades de polinização aberta apresentam potencial produtivo similar aos híbridos, e podem ser recomendadas para o cultivo em propriedades agrícolas de baixo poder aquisitivo (BISOGNIN et al., 1997). Pollination cultivars have great importance and economic viability for family farming and programs that value and disseminate their use should be valued for properties that adopt low and medium technological level.

CONCLUSIONS

Therefore, because of the aspects observed by cultivar SCS 155 Catarina, it presented the highest

cultivation cycle among cultivars and obtained the highest average cob diameter, corncob diameter, and weight of 1,000 grains.

The open pollination cultivars presented adequate agronomic performance and economic viability for cultivation in a low-altitude site in the central region of Rio Grande do Sul, standing out as an alternative of production and income for family farmers in the region.

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