http://journal.unoeste.br/index.php/ca/index
DOI: 10.5747/ca.2022.v18.n1.a478
ISSN on-line 1809-8215

Colloquium Agrariae

Submetido: 01/07/2021 Revisado: 15/10/2021 Aceito: 11/01/2022

Productivity of strawberry genotypes in the south and southwest mesoregion of Minas Gerais

Matheus Augusto Pereira[1], Luis Felipe Lima e Silva[1], Douglas Correa de Souza[2], Luciane Vilela Resende[2]

[1]Universidade José do Rosário Vellano – UNIFENAS, Campus Alfenas, MG. [2]Universidade Federal de Lavras – UFLA, MG. E-mail: luis.silva@unifenas.br; luisufla@hotmail.com

ABSTRACT

The strawberry is a perennial plant of temperate climate belonging to the Rosaceae family, much appreciated for presenting a fleshy and succulent receptacle as an edible part. Among small fruits, in Brazil it represents the species of greatest economic expression. The breeding of the strawberry aims to meet the demands of the market, mainly regarding the quality of the fruit required by consumers. Thus, the selection of genotypes that have good quality, productivity and adaptation is extremely important for the development of culture in the country, as well as for making seedlings available at lower prices. The objective of this work was to evaluate the agronomic performance and productivity of experimental strawberry genotypes in the city of Alfenas, Minas Gerais. For this, the experiment was carried out in the premises of the José do Rosário Vellano University (UNIFENAS), Alfenas-MG, in an experimental area of the Olericulture and Experimentation Sector (21025'45''S, 45056'50 "W, 880 m altitude). The experimental design used was completely randomized, with eleven treatments, distributed in seven experimental genotypes, namely MDA01, MDA06, MCA 119, MFA444, MDA19, MDA11 and MDA23, and four commercial cultivars taken as control, being them Pircinque, Albion, Aromas and Festival, in eight repetitions. The following characteristics were evaluated total production per plant (grams of strawberries per plant^{-1}), average weight of fruits per plant (grams/fruit^{-1}), total number of fruits per plant and number of stolons (seedlings) per plant. The experimental genotypes that showed the highest total productivity and average fruit weight were MDA01, MDA23 and MDA19. These materials are presented as promising for the strawberry breeding program in the region and should be reevaluated under other edaphoclimatic conditions and/or used as parents in new crossings for the next stages of the program.

Keywords: Adaptability; ecophysiology; red fruits; strawberry growing; *Fragaria × ananassa* Duch; strawberry breeding.

Produtividade de genótipos de morangueiro na mesoregião sul e sudoeste de Minas Gerais

RESUMO

O morangueiro é uma planta perene de clima temperado pertencente à família das Rosáceas, muito apreciado por apresentar um receptáculo carnoso e suculento como parte comestível. Entre os frutos pequenos, no Brasil representa a espécie de maior expressão econômica. O melhoramento genético do morangueiro visa atender às demandas do mercado, principalmente, quanto ao quesito qualidade do fruto exigido pelos consumidores. Dessa forma, a seleção de genótipos que apresentem boa qualidade, produtividade e adaptação, é de extrema importância para o desenvolvimento da cultura no país, bem como para a disponibilização de mudas com menores preços. Objetivou-se com este trabalho avaliar o desempenho agronômico e a produtividade de genótipos experimentais de morangueiro no município de Alfenas, Minas Gerais. O experimento foi conduzido nas dependências da Universidade José do Rosário Vellano (UNIFENAS), em área experimental do Setor de Olericultura e Experimentação. O delineamento experimental utilizado foi inteiramente casualizado, com onze tratamentos, distribuídos em sete genótipos experimentais provenientes do banco de germoplasma da Universidade Federal de Lavras, sendo eles MDA01, MDA06, MCA 119, MFA444, MDA19, MDA11 e MDA23, e quatro cultivares comerciais tidas como controle, sendo elas Pircinque, Albion, Aromas e Festival, em oito repetições. Foram avaliadas as seguintes

características: produção total por planta (gramas de morangos por planta), peso médio de frutos por planta (gramas/fruto), número total de frutos por planta e quantidade de estolões emitidos (mudas) por planta. Os genótipos experimentais que apresentaram os maiores índices de produtividade total e peso médio dos frutos foram MDA01, MDA23 e MDA19. Estes materiais se apresentam como promissores para o programa de melhoramento genético do morangueiro na região e devem ser reavaliados em outras condições edafoclimáticas e/ou utilizados como genitores em novos cruzamentos para as próximas etapas do programa.

Palavras-chave: Adaptabilidade; ecofisiologia; moranguicultura; *Fragaria × ananassa* Duch; melhoramento do morangueiro.

Introdução

The strawberry (*Fragaria × ananassa* Duch) is a species that stands out among all fruits, as it contains characteristics that can attract consumers, such as color, flavor, aroma and nutritional value. It has high versatility in its consumption, being able to be consumed *in natura* and in the industrialized form. Strawberry is commonly cultivated in temperate and tropical countries, with the world's largest producers being China, the United States, Spain and Japan, according to the Food and Agriculture Organization of the United Nations (FAOSTAT, 2016).

Strawberry, a pseudofruit of the strawberry plant, is highly appreciated worldwide, and consists of a very succulent and edible fleshy receptacle and has great social and economic importance and also has a growing demand by consumers around the world (MUNARETTO *et al.*, 2018).

With enormous socioeconomic importance, most of the cultivation areas in Brazil are located on family farming properties, with significant generation of jobs and income for families (ANTUNES *et al.,* 2016). However, with the absence of cultivars adapted to different Brazilian regions and their respective edaphoclimatic peculiarities, national farmers have higher expenses with the acquisition of seedlings (GALVÃO *et al.*, 2014; VIEIRA *et al.*, 2017).

The main strawberry cultivars grown in Brazil come from the United States (Aromas, Camarosa, Dover, Oso Grande and Sweet Charlie), from Spain (Milsei-Tudla), from the genetic plant breeding programs of Embrapa Clima Temperado and the Instituto Agronômico de Campinas - IAC (Campinas) (Bürkley, Santa Clara and Vila Nova) (OLIVEIRA *et al.*, 2005; GALVÃO *et al.*, 2014).

Furthermore, VIEIRA *et al.* (2017) reports that most strawberry cultivars grown in Brazil need a short photoperiod, that is, they flower when the day length becomes less than 12 hours, and the temperature is less than 15 °C. At seasons with different conditions, the emission of stolons occurs. However, there are cultivars that flower continuously, regardless of photoperiod, being called neutral cultivars. In this case, flowering ceases with temperatures equal to or below 10 °C, or above 28 °C.

Due to the edaphoclimatic diversity in the country, the small number of cultivars available in Brazil has been one of the main obstacles to the development of strawberry growing, both in regions that still do not produce, and in those where it is already cultivated. Therefore, it is important to encourage national programs for plant breeding and the introduction of new improved cultivars. In order to reduce costs and increase producers' income, the adaptability of cultivars to certain climatic conditions of cultivation is interesting, as this reduces the risk of economic damage to production, increasing the productive potential of the crop.

The selection of genotypes that present good productive quality in the region is extremely important for the development of strawberry crop in the country and for the reduction of costs in relation to the acquisition of seedlings. The main strawberry genotypes used in Brazil still come from the production of materials in programs carried out in other countries. The main materials used by Brazilian producers are Oso Grande, Camarosa, Aromas, Diamante, Caminho Real, Albion, Monterey, San Andreas, Palomar and Portola, developed at the University of California, and the cultivars Dover, Sweet Charlie and Festival, which were developed at the University of Florida. The dependence of national producers on these foreign genetic materials commonly results in an increase in the cost of

strawberry production in Brazil. There is a clear need to produce new genotypes that are adapted to the soil and climate conditions of each Brazilian region. To produce in the summer in long photoperiods and at high temperatures are still the main limitations of all genotypes currently available on the national market.

Given the importance of the culture for the southern region of Minas Gerais, it is essential to develop new cultivars that are adapted and demonstrate production stability in these places, as well as for other productive regions in Brazil. It is interesting to reduce the interaction of genotypes versus Brazilian environments, so that there is a better adaptability of materials, and greater predictability of these in different places. It is worth mentioning that the main cultivars available on the market today are imported, which were improved under climatic conditions of temperate countries (NICK; BORÉM, 2016).

Therefore, aiming at an initial population with great potential for selection of superior genotypes for the Mesoregion of the South and Southwest of Minas, genotypes that present good genetic divergence should be chosen, in order to avoid inbreeding, which often whether it will result in loss of productivity and vigor efficiency (RIOS, 2007; GIL-ARIZA *et al.*, 2009). Thus, the objective was to evaluate the productivity potential of experimental strawberry genotypes introduced in the region of Alfenas/MG.

Material and Methods

The experiment was carried out in the Experimentation and Olericulture sector of the José do Rosário Vellano University (UNIFENAS 21025'45''S, 45056'50"W, 880m altitude), Alfenas-MG, a municipality located in the South and Southwest Mesoregion of Minas Gerais, implemented on June 1, 2020 and conducted until October 5, 2020.

The design used was completely randomized, with ten replications per genotype, with one pot considered a repetition, totaling 110 plants. The cultivation was carried out in a protected system in a greenhouse, in 8dm³ pots.

The pots were filled with Latosol, which was corrected with limestone in order to raise the base saturation index to 70%. Nutrition recommendations were made according to soil chemical analysis (Table 1), and average to low availability of nutrients in general, according to average requirements for the strawberry crop (FILGUEIRA, 2013; RIBEIRO, 1999). Irrigations were performed manually by weight difference, with soil moisture being raised to field capacity daily. The water depth was calculated based on the weight of the pots in relation to the field capacity.

Tabela 1. Chemical analysis of the soil used in the experiment.

OM	pH	P-	K+	Ca^{2+}	Mg^{2+}	Al^{3+}	H+Al	SB	CTC	V	M
	$CaCl_2$	Mehlich									
g/dm³		----mg dm^{-3}--		---------- $mmol_c$ dm^{-3} -------						---- % ----	
8	4,6	3	1,2	5	2	0,00	22	8,2	30,2	27	1

OM – organic matter; H+Al – potential acidity; SB – sum of bases; CTC – cation exchange capacity at pH 7.0; V – base saturation; m – saturation by $Al3^{+}$.

The preventive management of pests and diseases was carried out with fortnightly applications alternating the Neem, garlic, tobacco and Bordeaux mixtures, according to the production and application techniques illustrated by de Jesus (2021).

Eleven strawberry genotypes were evaluated (Table 2), four commercial cultivars and seven genotypes belonging to the genetic improvement program of the Federal University of Lavra-UFLA, previously selected for their productive characteristics and the physicochemical quality of the fruits (GALVÃO *et al.*, 2014; SOUZA *et al.*, 2019; VIEIRA *et al.*, 2017).

The experimental genotypes tested were obtained through crosses between parents selected by the strawberry breeding program of the Federal University of Lavras (UFLA). The parents were selected because they present characteristics of agronomic interest and because they are among the materials widely planted in Brazil, which present appreciable characteristics. The experimental genotypes tested were obtained from the offspring of crosses between

commercial cultivars as parents, as shown in Table 2.

Table 2. Description of the 7 experimental strawberry genotypes tested, their parents in the original hybridization and the 4 cultivars taken as control.

Genotype	Origination
MDA01	DOVER X AROMAS
MDA06	DOVER X AROMAS
MCA 119	CAMAROSA X AROMAS
MFA444	FESTIVAL X AROMAS
MDA19	DOVER X AROMAS
MDA11	DOVER X AROMAS
MDA23	DOVER X AROMAS
Pircinque	Commercial cultivar
Albion	Commercial cultivar
Aromas	Commercial cultivar
Festival	Commercial cultivar

Among the parent materials, only 'Aromas' is a neutral-day cultivar, the others are short-day cultivars. The genotypes were propagated asexually and cultural treatments such as irrigation and crop nutrition were carried out according to the technical indications for the crop (FILGUEIRA, 2013). As a result of the harvests (end of August to beginning of November) the following evaluations were carried out: total production per plant (grams of strawberries per plant), average weight of fruits per plant (grams/fruit), total number of fruits per plant and number of emitted stolons (seedlings) per plant.

Figura 1. Experimental strawberry genotypes in Alfenas-MG.



The data were then submitted to analysis of variance by the Sisvar software (FERREIRA, 2011). Results with significant differences were submitted to the Scott-knott test at 5% in order to compare the means regarding the results obtained between the characteristics evaluated in each experimental genotype.

In order to make the complete characterization and grouping of strawberry genotypes possible, taking into account all the characteristics evaluated, the dissimilarity dendrogram was prepared, according to the Euclidean distance, with the aid of the Chemoface program, version 1.4 (NUNES *et al.*, 2012).

Results and Discussion

The experimental strawberry genotypes tested differed (P<0.01) in relation to total yield in grams. The experimental genotypes MDA19, MDA01 and MDA23 showed the highest yields per plant, which averaged 91.11 grams, which did

not differ significantly from each other for this criterion (Table 3). These genotypes also presented yield averages similar to those observed for the controls 'Aromas' and 'Festival'.

The experimental genotypes tested here were created through a broad program of strawberry breeding, and developed with selections for adaptability and yield stability in the region of Lavras-MG (GALVÃO *et al.*, 2014). The materials already had productive potential in the south of Minas Gerais, in the region where they were improved. The data indicate that the experimental genotypes MDA19, MDA01 and MDA23 showed good yield potential. It is observed that some of the evaluated genotypes are as or more productive in total quantity as the imported commercial genotypes. These materials should be better studied in terms of their photoperiod and temperature demands, the main still limiting factors for strawberry cultivation in Brazil in practically all cultivars currently adopted in the country. In addition, the data indicate that these materials can serve as parents aiming at the next steps of a strawberry genetic breeding program for the region.

The experimental genotypes named MDA11, MCA119, MDA06 and MFA444 showed the lowest average total productivity (61.39 grams per plant), and did not differ significantly from the values observed for the controls 'Albion' and 'Pircinque'. These data indicate that in terms of total production in the period studied, these materials were lower. However, more details still need to be investigated, such as evaluations of the new experimental genotypes not only referring to the total produced, but also to the total productions in different climatic seasons of the agricultural year in the south of Minas Gerais, as well as other strawberry quality characteristics.

Table 3. Productivity (grams per plant), total number of fruits and average weight of fruits (grams/fruit) of different experimental strawberry genotypes evaluated in the region of Alfenas-MG.

Genotypes	Evaluation Attributes - Averages[1]		
	Productivity	Total No. of Fruits	Average weight/fruit
Festival	121,60 a	13,75 a	9,18 b
MDA19	97,57 a	11,5 a	8,98 b
MDA01	90,09 a	8,9 b	11,85 a
MDA23	85,67 a	8 b	11,22 a
Aromas	81,31 a	9,13 b	9,30 b
MFA444	69,20 b	8,9 b	7,75 b
MDA06	66,96 b	7,5 b	9,11 b
Pircinque	68,33 b	7 b	9,70 b
Albion	66,05 b	6,5 b	10,36 a
MCA119	59,96 b	7,9 b	7,03 b
MDA11	49,42 b	6,5 b	7,48 b
CV%	12,30%	21,16%	11,57%

1 – Means followed by the same letter do not differ from each other by the Scott-Knott test, considering the 5% significance level.

In order to also evaluate the number of strawberries produced per plant, these were counted. The total numbers of strawberries for each genotype tested differed statistically from each other at the 5% probability level. The experimental genotype MDA19 had the highest number of strawberries per plant, and did not differ significantly from the 'Festival' control, which, on average, produced 13 fruits per plant.

The genotypes MDA11, MDA6, MCA119, MDA23, MDA01 and MFA 444, and the controls Albion, Aromas and Pircinque, did not differ significantly from each other for the total number of fruits per plant, which, on average, produced 8 fruits per plant. As a result, the average weight of each strawberry per plant also varied significantly.

The experimental genotypes MDA01, MDA23, MDA06 and MDA19 presented the highest average fruit weights, which stood out significantly from the others. These data indicate that these experimental genotypes, mainly the materials MDA1, MDA23 and MDA19, in addition to being productive in total quantity in grams per

plant, also stood out in relation to the average weight of their strawberries, that is, they produced larger fruits, which is very desirable for the fresh strawberry market.

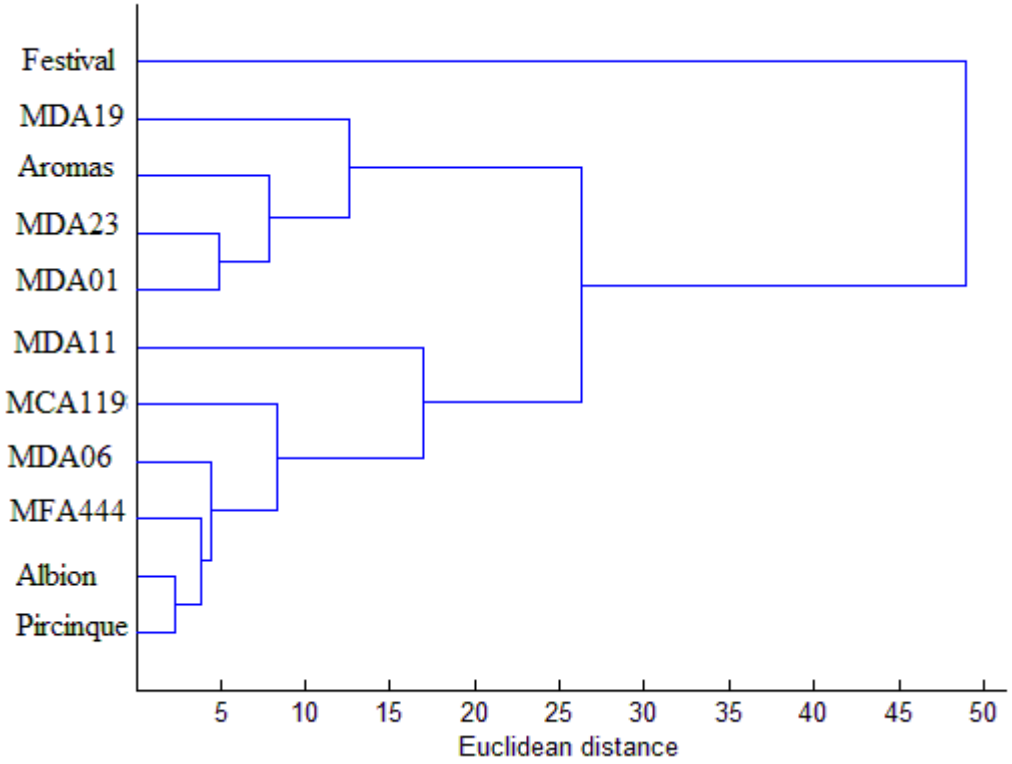
The genotypes MCA119, MDA11, and MFA444, in turn, had the lowest average fruit weight. These genotypes also showed the lowest total yields per plant.

As a result, the experimental genotypes MDA01, MDA23 and MDA19 showed the best yield potential in the region, both in terms of total yield and in terms of number and weight of their fruits. These materials are promising for the beginning of the strawberry genetic breeding program in the region of Alfenas - MG and in regions with similar edaphoclimatic conditions, and should be reassessed in other conditions and places and/or used as parents in new crosses for the next steps of the program.

The strawberry plant is commonly propagated asexually and its seedlings are produced through stolons. It is convenient that new materials are productive, with a wide range of resistance to pests and diseases, and also with good potential for producing stolons for the production of seedlings. Therefore, the materials were also evaluated to verify the seedling production potential per plant. There were no significant differences in the production of seedlings and stolons per plant. On average, both the experimental genotypes and the commercial cultivars used as control showed about two stolons/seedlings produced per plant.

The analysis of production components, considering the similarities between the genotypes and commercial materials evaluated, led to the formation of three groups, according to the dendrogram (Figure 2).

Figura 2. Dissimilarity dendrogram with Euclidean distance produced according to the similarities of observations carried out on experimental strawberry genotypes in the city of Alfenas-MG.



Festival stood out from the other materials in relation to all the categories evaluated, and remained isolated in the dendrogram. The other genotypes were divided, according to similarities, into two groups: the first group formed by genotypes MDA 19, Aromas, MDA 23 and MDA 01; and the second group formed by the genotypes MDA 11, MCA 19, MDA 06, MFA 444, Albion and Pircinque. These divergences point to potential parents for the next phases of this program, emphasizing that divergent materials can be used as parents in order to increase the genetic variability of the

program through controlled crossings between plants of different experimental genotypes.

All experimental genotypes tested showed similar or superior productivity to those taken as controls, traditionally cultivated in Brazil. The genotypes MDA01, MDA23 and MDA19 showed the highest yield potential. These materials were promising for the beginning of strawberry genetic improvement programs for the region in question, also aiming at other crosses in the future with divergent materials and the expansion of the number of genotypes, as well as their genetic variability in this program.

Conclusion

The experimental genotypes that showed good potential for production in the Mesoregion of the South and Southwest of Minas Gerais were MDA01, MDA23 and MDA19.

References

ANTUNES, L. E. C.; REISSER JÚNIOR, C.; SCHWENGBER, J. E. **Morangueiros**. Brasília, DF: Embrapa, 2016. Disponível em: https://ainfo.cnptia.embrapa.br/digital/bitstream/item/179724/1/Luis-Eduardo-MORANGUEIRO-miolo.pdf. Acesso em: 04 maio 2021.

JESUS, G. T. **Caderno agroecológico**: produção de insumos para controle de insetos e doenças na horticultura. Bahia: Instituto Federal, 2021.

FAO. **Food and Agriculture Organization of the United Nations.** (2016). Disponível em: http://faostat.fao.org. Acesso em: 03 maio 2021.

FERREIRA, D. F. Sisvar: a computer statistical analysis system. **Ciência e Agrotecnologia**, v. 35, n. 6, p. 1039-1042, 2011.

FILGUEIRA, F. A. R. **Novo manual de olericultura**: agrotecnologia moderna na produção e comercialização de hortaliças. 3. ed. Viçosa: UFV, 2013. 402 p.

GALVÃO, A. G. *et al.* Over coming strawberry achene dormancy for improved seedling production in breeding programs. **Idesia**, Chile, v. 32, n. 4, 2014. https://doi.org/10.4067/S0718-34292014000400007

GIL-ARIZA, D. J.; AMAYA, I.; LÓPEZ-ARANDA, J. M.; SÁNCHEZ-SEVILLA, J. F. Impact of plant breeding on the genetic diversity of cultivated strawberry as revealed by expressed sequence tag-derived simple sequence repeat markers**. Journal of the American Society for Horticultural Science**, v. 134; n. 3, p. 337-347, 2009. https://doi.org/10.21273/JASHS.134.3.337

MUNARETTO, L. M.; BOTELHO, R. V.; RESENDE, J. T. V; SCHWARZ, K., SATO, A. J. Productivity and quality of organic strawberries pre-harvest treated with silicon. **Horticultura Brasileira**, v. 36, n. 1, p. 40-46, 2018. https://doi.org/10.1590/s0102-053620180107

NICK, C.; BORÉM, A. **Melhoramento de hortaliças**. Viçosa: UFV, 2016. 464 p.

NUNES, C. A.; FREITAS, M. P.; PINHEIRO, A. C. M.; BASTOS, S. C. Chemoface: a novel free user-friendly interface for chemometrics. **Journal of the Brazilian Chemical Society**, v. 23, n. 11, p. 2003-2010, 2012. https://doi.org/10.1590/S0103-50532012005000073

OLIVEIRA, R. P; NINO, A. F. P; SCIVITTARO, W. B. Mudas certificadas de morangueiro: maior produção e melhor qualidade da fruta. **A Lavoura**, v. 108, p. 35-38, 2005.

RIBEIRO, A. C. **Recomendação para o uso de corretivos e fertilizantes em Minas Gerais**. 5. ed. Viçosa: Comissão de Fertilidade do Solo do Estado de Minas Gerais, 1999.

RIOS, S. Melhoramento genético do morangueiro. **Informe Agropecuário**, v. 28, n. 1, p. 14-19, 2007.

SOUZA, D. C.; OSSANI, P. C.; Resende, L. V.; CIRILLO, M. A.; SILVA, L. F. L.; XAVIER, J. B. Variabilidade genética entre cultivares comerciais e híbridos experimentais de morangueiro com ênfase em análise de múltiplos fatores. **Magistra Cruz das Almas**, v. 30, p. 48-59, 2019.

VIEIRA, S. D.; SOUZA, D. C.; MARTINS, I. A.; RIBEIRO, G. H. M. R.; RESENDE, L. V.; FERRAZ, A. K. L.; GALVÃO, A. G.; RESENDE, J. T. V. Selection of experimental strawberry (*Fragaria* x *ananassa*) hybrids based on selection indices. **Genetics and Molecular Research**, v. 16, n. 1, 2017. https://doi.org/10.4238/gmr16019052