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Propagation

Evidence of maternal effect on germination and vigor of sour passion fruit

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Abstract - The seminiferous propagation of Sour Passion Fruit (*Passiflora edulis* Sims) is the main kind of multiplication due to the ease formation of seedlings. However, the reduced number of productive and homogeneous cultivars reflects the need for genetic breeding. The objective of this study was to assess the maternal and reciprocal effects in vigor and germination of Sour Passion Fruit seeds. The experiment was conducted in a completely randomized design in the factorial scheme, with two structure (hybrid and reciprocal) and ten crosses with four replicates (50 seeds) in trays containing inert sand in germination chamber. Before sowing, it was obtained the weight of 100 seeds, and at 28 days germination percentage, emergence speed index, total seedlings length, shoot length and main root length, number of normal seedlings and dry mass per seedlings were evaluated. The reciprocal effects tell us which genotype is most promising when used as the female or male parent for the trait studied. It can be inferred that there is maternal effect influencing the weight of 100 seeds, emergence, emergence speed index and the number of normal seedlings. There was influence of the parent on the expression of traits in seeds of Sour Passion Fruit. It is important to define the paternal and maternal parent to obtain seeds with high germination potential.
Index terms: *Passiflora edulis* Sims, reciprocal effect, hybrid breeding, seeds.

Evidências do efeito materno na germinação e no vigor de maracujá azedo

Resumo - A propagação seminífera de maracujá azedo (*Passiflora edulis* Sims) é o principal tipo de multiplicação devido à facilidade na formação de mudas. No entanto, o reduzido número de cultivares produtivas e homogêneas reflete a necessidade de melhoramento genético. O objetivo deste trabalho foi avaliar os efeitos maternos e recíprocos no vigor e na germinação de sementes de maracujá. O experimento foi conduzido em delineamento inteiramente casualizado, no esquema fatorial, com duas estruturas genéticas (híbrido e recíproco) e dez cruzamentos, com quatro repetições (50 sementes), em bandejas contendo areia inerte na câmara de germinação. Antes da semeadura, foi obtido o peso de 100 sementes, e aos 28 dias, foram avaliados a porcentagem de germinação, o índice de velocidade de emergência, comprimento total de plântulas, comprimento de parte aérea e raiz principal, número de plântulas normais e massa seca por plântulas. Os efeitos recíprocos dizem qual genótipo é mais promissor quando usado como genitor feminino ou masculino para a característica estudada. Pode-se inferir que há efeito materno influenciando o peso de 100 sementes, a emergência, o índice de velocidade de emergência e o número de mudas normais. Houve influência dos pais na expressão de caracteres em sementes de maracujá azedo. É importante definir os pais paterno e materno para obter sementes com alto potencial de germinação.
Termos para indexação: *Passiflora edulis* Sims, efeito recíproco, híbrido, sementes.

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Introduction

Passifloraceae family has an expressive number of species, which the most cultivated is *Passiflora edulis* Sims, popularly known as Sour Passion Fruit (SPF) (BERNACCI et al., 2008). In recent years there has been an increase in the cultivation of the species *P. alata* Curtis, *P. setacea* DC. and *P. cincinnata* Mast., however, Gioppato et al. (2018) report that Sour Passion Fruit is the most cultivated specie in the commercial orchards due to consumer's appreciation of their fruits and the encouragement of agribusiness. Sour Passion Fruit crop stands out in the national scenario of fruit production because it offers a rapid return on capital and the opportunity of a more distributed income throughout the year (ARAÚJO NETO et al., 2009; MELETTI, 2011).

Sour Passion Fruit has seeds as a major mean of propagation (SILVA et al., 2015). Therefore, this method presents a great lack of uniformity in germination and seedlings formation making the process expensive and time-consuming (SOUTO et al., 2017a). Moreover, commercial crops are mostly composed of varieties that presents genetic variability (ROSADO et al., 2019), because the specie is allogamous and autoincompatible (SUASSUNA et al., 2003),) which causes heterogeneity of the plants.

Genetic breeding of SPF promoted significant advances and contributed to increasing productivity, fruit quality and resistance to important diseases of the crop (SANTOS et al., 2008, CAVALCANTE et al., 2019, WU et al., 2020). Therefore, the quality of seeds used is a fundamental factor for the success of crops, since it affects the yield and quality of the final product. The demand for SPF hybrids seeds with high quality has increased significantly in the last years, mainly due to the competitiveness of the market and the lack of resistant genotypes to emergent diseases or pathogens races (FALEIRO et al., 2019).

Thus, one of the great challenges that breeders faced is to group into a genotype the greatest number of desirable traits and, in the case of SPF, to obtain fruits with high quality, resistance to the main diseases and seeds with high germinative potential. The percentage of germination and vigor of seedlings are factors that must be considered in the genetic breeding of SPF (SOUTO et al., 2017b).

The success of SPF hybrids' performance for traits having agronomic interest is a result of the heterotic effect achieved by the crossbreeding of progenies that have a good combining ability. The heterosis manifestation in hybrids for traits related to the physiological quality of seeds indicates the feasibility of obtaining hybrid cultivars with high-quality seeds. According to Padua et al. (2011), the low germination of Passiflora seeds may be caused by genetic origin due to variation between species and cultivars.

However, some difficulties and limitations during the realization of the crossing have been observed, such as the auto-incompatibility, which causes the absence of fruiting between parents with equal alleles. An alternative for that is obtaining compatible crosses, with the production of high-quality seedlings. The choice of parents to be hybridized plays an important role in breeding programs to obtain sufficiently heterotic hybrids and consequently, superior segregants (VIANA et al., 2007). Another factor to be considered is the direction of the crossing, i.e. which plant will be established as a pollen donor and which will be used as the pollen recipient. Nascimento et al. (2016) concluded that the crossing directions influence considerably the germination in tomato, evidencing a significant parental effect of hybrids.

On the other hand, little is known regarding the genetic improvement of SPF, the structuring of crosses to obtain seeds and the genetic influence in the formation of seedlings with adequate traits, such as germination, emergence, and vigor. These studies are recommended to identify superior genotypes having good germination and seedling development, essential in the initial establishment of plants.

Therefore, the objective was to evaluate the germination and seed vigor coming from the hybrid and reciprocal structure, in order to detect maternal and reciprocal effect to facilitate the development of new commercial hybrids.

Materials and methods

The experiment was carried out in a germination chamber at the Department of Agronomy of the Universidade Federal de Viçosa (UFV), in the city of Viçosa, Minas Gerais, Brazil. Controlled hybridizations were performed among genotypes of UFV Sour Passion Fruit Breeding Program, commercial varieties from Empresa Brasileira de Pesquisa Agropecuária (Embrapa) and Viveiro Flora Brasil (FB).

Genotypes tested were selected by traits, such as yield, fruit quality, and disease tolerance. The selected genotypes were planted in plastic pots of 40 L in a greenhouse, with substrate in the proportion 3:1:1 (soil: sand: manure) and acidity correction (dolomitic limestone) and phosphatization (single superphosphate). During the development of plants, pruning, irrigation, complementary fertilization and management were performed to obtain the fruits.

Hybridizations were carried out protecting the flowers destined to provide and receive the pollen, in the morning, before the anthesis, with a bag of paraffin wax paper. After opening the flower, the bag was removed from the donor flower and the pollen was collected using a cotton swab; then the pollen was transferred to the recipient flower, removing the bag to carry out the pollination. Then, a protective bag was put back onto the flower, duly identified with the crosses and pollination date. After one week, the fruit setting of the crossing was identified, and the bagging was carried out with a nylon net and the identification of the crossing with plastic label fixed to the nylon net.

Hybridizations were delineated according to the hybrid and reciprocal structure. Twenty progenies were formed, crossing 10 genotypes, which were pollen donors (male parent) and recipients (female parent), generating a hybrid and a reciprocal cross (Table 1). Four fruits were harvested by crossing, two of the hybrids and two of the reciprocals, between 60-90 days after pollination. It was used as criterion for harvesting the change of the fruit color, from green to yellow, showing 5% of yellow color on its surface.

The seeds were extracted from the fruits by opening through a cross-section of the fruit, afterward, the pulp, composed of juice and seeds was wrapped in a fine-mesh sieve and by the friction of the pulp with the aid of 10% lime, the aryl was removed from the seeds.

The experiment was conducted in a factorial scheme in a completely randomized design, with two structures (hybrid and reciprocal) and 10 crosses (in four replicates (Table 1). Each plot consisted of 50 seeds, placed to germinate in plastic trays containing washed and inert sand, at 2.0 cm depth. After sowing, the trays were placed in germination chambers, with controlled temperature and luminosity, 8 hours at 30 ºC with light, and 16 hours at 20 ºC in the dark. Irrigation was performed daily with distilled water.

Table 1. Relation of SPF hybrids and reciprocal, its ancestry, and origin. Viçosa – MG, 2015.

Crosses	Hybrid (♀ x ♂)	Reciprocal (♀ x ♂)
1	UFV 23 (1) x UFV 21 (1)	UFV 21 (1) x UFV 23 (1)
2	UFV 21 (11) x BRS GA1 (22)	BRS GA1 (22) x UFV 21 (11)
3	BRS GA1 (2) x BRS RC1 (2)	BRS RC1 (2) x BRS GA1 (2)
4	UFV 15 (1) x UFV 20 (1)	UFV 20 (1) x UFV 15 (1)
5	UFV 16 (1) x UFV 1 (1)	UFV 1 (1) x UFV 16 (1)
6	FB200 (33) x BRS RC1 (2)	BRS RC1 (2) x FB200 (33)
7	UFV 20 (1) x UFV 21 (11)	UFV 21 (11) x UFV 20 (1)
8	UFV 1 (1) x UFV 23 (11)	UFV 23 (11) x UFV 1 (1)
9	BRS GA1 (2) x UFV 1 (1)	UFV 1 (1) x BRS GA1 (2)
10	BRS RC1 (22) x UFV 1 (11)	UFV 1 (11) x BRS RC1 (22)

Genotypes origin: (1), Genetic Breeding Program of Sour Passion Fruit of UFV – progenies of full-sibling; (2), Embrapa; (3), Viveiro Flora Brasil.

The eight traits evaluated on seeds and seedlings were: weight of 100 seeds (WS) in grams (g), emergence (EME) in percentage (%), emergence speed index (ESI); total length of seedlings (TLS), length of main root (LR) and shoot (LS) in centimeters (cm); number of normal seedlings (NNS) and dry mass per seedling (DMS) in milligrams (mg).

The weight of 100 seeds was counted by weighing four samples of 100 seeds for each hybrid and/or reciprocal on an analytical scale (0.001 g) before sowing. The emergence and emergence speed index were evaluated daily by visual method, according to the Rules for Seed Analysis - RAS (BRASIL, 2009), considering seedlings when it was possible to visualize the emission of the cotyledons loop. Finally, the percentage of emergence was calculated using the count of emerged seedlings at the 28th day of evaluation.

The emergency speed index was determined according to Maguire (1962): ESI = (N1 G1) + (N2 G2) + ... + (NnGn) / (G1 + G2 + ... + Gn) where: N1 = number of days for the first count; G1 = number of emerged seedlings on the first count; N2 = number of days for the second count; G2 = number of emerged seedlings in the second count; Nn = number of days for the last count; Gn = number of emerged seedlings at the last count.

The total length of seedlings (length of the main root and the shoot) was measured with the aid of a ruler graduated in millimeters at the end of the 28th day after assembly the experiment. All normal seedlings of each treatment and replicate were measured separately in order to obtain an average. Normal seedlings number was counted in a simple count at the 28th day of the experiment, selecting seedlings that emerged completely and did not present any type of anomaly.

The dry mass per seedlings was obtained as follows: the normal seedlings at the 28th day were packed in paper bags and placed in a drying oven at 65 ºC for 72 hours. After, the total dry mass of the seedlings was weighed in a semi-analytical scale, which was divided by the number of normal seedlings, obtaining the dry mass per seedling.

The analysis of variance (ANOVA) was performed by the Hierarchical Model of the Genetic Structure in hybrid and reciprocal. The model was established with all fixed effects, as follows: $Y_{ijk} = \mu + S_i + C/S_{ij} + E_{ijk}$, where, Y_{ijk} is the observation regarding the crossing between parents; μ is the general average; S_i is the effect relative to the structures of order i; order j; C/S_{ij} is the effect of the crosses inside of structure of order ij; and E_{ijk} is the experimental error. After ANOVA processing, the Tukey averages test was performed at 5% probability level. The analysis was performed using the GENES software application (CRUZ, 2013).

Results and discussion

In this study, 20 crosses were developed producing 10 hybrid and 10 reciprocal progenies in order to evaluate traits related to germination and vigor of seeds and seedlings of SPF.

Crosses (C) differed from each other regarding all traits evaluated; however, structures (S) did not differ (Table 2). It was verified the interaction between crosses and structure in four traits: weight of 100 seeds, emergence, emergence speed index and the number of normal seedlings, resulting in differences in the structures within the crosses (S/C) which demonstrate a different behavior among hybrids and reciprocals for these traits. The overall seedling emergence average of progenies was 87.15%. This result demonstrates the germinative potential of the genotypes used in this study. The coefficient of variation (CV) for the weight of 100 seeds presented the lowest value (0.62%) and the dry mass per seedling showed the highest value (12.87%). The low magnitude of CV values reached in this experiment evidence a high experimental precision.

Table 2. ANOVA of SPF hybrid progenies structured in hybrid and reciprocal. Viçosa-MG, 2015.

Fator	DF	Mean Square							
		WS	EME	ESI	TLS	LR	LS	NNS	DMS
C	9	0.687**	1788.350**	6.131**	2.996**	1.076**	1.342**	277.827**	9.223**
S	1	0.026ns	168.200ns	0.529ns	0.208ns	0.174ns	0.009ns	96.800ns	0.088ns
C x S	9	0.218**	443.640**	0.950**	0.770ns	0.509ns	0.220ns	112.744**	1.237ns
C/S	18	0.452**	1116.000**	3.541**	1.883**	0.793**	0.781**	277.827**	5.230**
C/S 1	9	0.665**	1194.930**	3.600**	1.905**	0.443ns	0.936**	294.333**	5.524**
C/S 2	9	0.240**	1037.060**	3.482**	1.861**	1.143**	0.626*	261.322**	4.936**
S/C	10	0.199**	416.100**	0.908**	0.714ns	0.476ns	0.198ns	111.150**	1.122ns
S/C 1	1	0.003**	0.500ns	0.112ns	0.107ns	0.615ns	0.208ns	0.125ns	0.194ns
S/C 2	1	0.000ns	18.000ns	0.020ns	0.985ns	0.051ns	0.587ns	4.500ns	0.854ns
S/C 3	1	0.008**	648.000**	1.123**	0.262ns	0.298ns	0.001ns	171.125**	0.065ns
S/C 4	1	0.015**	12.500ns	3.000**	0.275ns	0.486ns	0.250ns	0.125ns	0.943ns
S/C 5	1	0.001*	2.000ns	0.055ns	0.010ns	0.011ns	0.046ns	2.000ns	0.161ns
S/C 6	1	0.056**	50.000ns	0.010ns	2.618*	1.916*	0.054ns	4.500ns	1.085ns
S/C 7	1	0.299**	3042.000**	3.142**	0.116ns	0.018ns	0.042ns	760.500**	1.878ns
S/C 8	1	0.055**	18.000ns	0.003ns	0.106ns	0.171ns	0.007ns	112.500*	0.497ns
S/C 9	1	0.491**	338.000**	0.451*	0.108ns	0.674ns	0.242ns	50.000ns	0.625ns
S/C 10	1	1.062**	32.000ns	1.166**	2.549*	0.519ns	0.767ns	6.125ns	4.919*
Residual	60	0.011	1806.000	5.867	23.342	20.345	14.770	1127.500	64.719
Average	-	2.255	87.150	3.166	10.338	5.584	4.753	43.100	8.064
CV (%)	-	0.620	6.290	9.870	6.030	10.420	10.430	10.050	12.870

**, * F significant at the level of 1% and 5% probability, respectively. ns F not significant at the 5% level. DF: degrees of freedon, WS: weight of 100 seeds (g), EME: emergence (%), ESI: emergence speed index, TLS: total seedling length (cm), LR: main root length (cm), LS: shoot length (cm), NNS: number of normal seedlings and DMS: dry mass per seedling (mg) at different crosses (C) and structured (S) in hybrids and reciprocal.

The results obtained demonstrate the genetic variability in the crosses for the emergence and vigor traits. In general, the hybrids and reciprocal showed similar values for the traits under study. Depending on the crosses or structure used there may be a variation of these traits.

The trait weight of 100 seeds presented a significant difference among the structures for almost all crosses, except cross 02. In addition to the weight of 100 seeds, crosses 03 and 07 differed equally for emergence, emergence speed index and the number of normal plants. Like this within crosses 04, the structures also differed significantly for the emergency speed rate. In crosses 06, the structures showed divergent results in total length and the main root. Crosses 08 differed in the number of normal seedlings; crosses 09 differed both to the emergency and the rate of emergency speed. Finally, in crosses 10, the structures differed according to the emergence speed rate, total length and dry mass per seedling.

As verified, the study points to the necessity to determine which parent will be used as a pollen donor and pollen recipient from another parent in the pollination. The variations among the structures for the emergence and vigor traits within each crossing indicate that there is interference related to the cytoplasmic effect. In a study conducted by Cabral et al. (2013), it was verified the existence of a reciprocal effect pronounced for the quality of popcorn seeds, requiring that the male and female parents should be determined before crossing.

As studied by Rêgo et al. (2009), the direction of the crossing in pepper (*Capsicum baccatum* L.) to obtain seeds, influence on fruit quality and expression of the best traits of each parent. For Foster (1986), the seed size may be related to the amount of reserves; seeds with larger size occurs faster synthesis of important secondary compounds in the germination process. Moreover, there is also a higher production of photosynthetic compounds for seedlings growth, with a higher chance of survival under adverse conditions.

The endosperm that is the reserve tissue that feeds the embryo is formed by the fusion among a male gamete and two polar cores of the female gametophyte. After fusion these three cells, a triploid nucleus gave rise having in its genome two copies of the maternal alleles and a copy of the paternal allele. Therefore, the constitution of this tissue is predominantly governed by the female parent (WU et al., 2002). From these results it can be inferred that there is a cytoplasmic effect of the female parent influencing the traits among the structures at the crossing, and it is necessary to direct the crossing choosing the female parent that will allow the greater weight of the seeds.

The variation in the weight of 100 seeds indicates that the crossover (parents) and the crossover direction interferes with this trait being this difference related to the maternal inheritance. Wolf and Wade (2009) define maternal effect, in general, as the influence caused by the genotype or maternal phenotype on the phenotype of the offspring and may be caused by post-zygotic influences through maternal traits such as nutritional provision, seed architecture and dispersion forms.

Gonzalo et al. (2007), mapping reciprocal effects in corn, found that the seed weight has a maternal influence occurring in conjunction with other factors, such as cytoplasmic effects and 'parent-of-origin' effects. Similarly, Nascimento et al. (2016) observed in tomatoes that the direct crosses and in reciprocal crosses (considering the temperature resistance trait) evidenced the effect of the parents on the hybrids, occurring a significant maternal effect in the San Vito and Fontana cultivars and paternal effect in the Finestra cultivar.

After performed the analysis of variance, the Tukey test was applied to rank significant averages in order to identify superior genotypes. Table 3 shows that the reciprocal of crosses 01, 03, 04, 05, 06, 07 and 09 presented a higher average than the hybrids for the trait weight of 100 seeds. Hybrids of crosses 08 and 10 presented a higher average than reciprocals. At crosses 02, hybrid and reciprocal did not differ statistically. The hybrid with the highest weight of 100 seeds was the hybrid referring to crosses 10 (2.88 g); in the reciprocal crosses were 03 and 06 (2.50 and 2.51 g). Numerically the hybrid of crosses 10 was the one that obtained the greater weight of 100 seeds between hybrids and reciprocal of all the crosses.

Table 3. Average of traits from SPF progenies structured in hybrid and reciprocal. Viçosa- MG, 2015.

Trait	Structure	Crosses									
		01	02	03	04	05	06	07	08	09	10
WS	H	2.36Bc	2.25Ad	2.43Bb	2.14Be	2.24Bd	2.34Bc	1.28Bg	2.41Ab	1.97Bf	2.88Aa
	R	2.40Ac	2.25Ade	2.50Aab	2.23Ae	2.27Ad	2.51Aa	1.67Ag	2.25Bb	2.47Ab	2.15Bf
EME	H	100.00Aa	96.00Aa	63.50Ac	97.00Aa	96.50Aa	87.50Aab	47.00Bd	91.50Aab	82.50Bb	95.50Aa
	R	99.50Aa	99.00Aa	45.50Bd	94.50Aab	97.50Aab	82.50Ac	86.00Abc	94.50Aabc	95.50Aab	91.50Aabc
ESI	H	4.16Aa	4.41Aa	2.13Ade	2.90Bbc	2.98Abc	2.38Acd	1.63Be	3.35Ab	2.64Bbcd	4.23Aa
	R	4.40Aa	4.31Aa	1.38Be	4.13Aab	3.15Ac	2.30Ad	2.88Acd	3.31Ac	3.11Ac	3.47Bbc
TLS	H	10.36Aabc	10.32Abc	10.30Abc	10.42Aab	10.55Aab	10.16Abc	8.94Ac	10.30Abc	10.68Aab	11.81Aa
	R	10.60Aab	11.02Aa	9.94Aabc	10.79Aa	10.62Aab	9.02Bc	9.18Abc	10.53Aab	10.45Aabc	10.68Ba
LR	H	5.36Aa	5.90Aa	5.63Aa	5.62Aa	5.64Aa	5.70Aa	4.84Aa	5.95Aa	5.67Aa	5.97Aa
	R	5.91Aab	6.06Aab	5.24Aab	6.11Aa	5.56Aab	4.72Bb	4.94Aab	6.24Aa	5.08Aab	5.46Aab
LS	H	5.00Aab	4.41Ab	4.67Ab	4.79Aab	4.91Aab	4.46Ab	4.10Ab	4.35Ab	5.01Aab	5.83Aa
	R	4.68Aa	4.96Aa	4.69Aa	4.68Aa	5.06Aa	4.30Aa	4.24Aa	4.29Aa	5,36Aa	5.21Aa
NNS	H	49.0Aa	48.00Aa	31.75Abc	48.25Aa	47.75Aa	43.25Aa	23.25Bc	39.75Bab	40.75Aab	47.75Aa
	R	49.75Aa	49.50Aa	22.50Bb	48.00Aa	48.75Aa	41.75Aa	42.5Aa	47.25Aa	45.75Aa	46.00Aa
DMS	H	8.05Aabc	7.04Abc	8.27Aabc	7.94Aabc	8.53Aab	9.15Aab	5.98Ac	7.45Abc	8.17Aabc	10.35Aa
	R	8.37Aa	7.70Aa	8.45Aa	8.62Aa	8.25Aa	8.41Aa	5.01Ab	7.95Aa	8.73Aa	8.78Ba

Mean values followed by the same lowercase letter in the line and uppercase letter in the column do not differ statistically by the Tukey´s test at the level of 5% probability. WS: weight of 100 seeds (g), EME: emergence (%), ESI: emergence speed index, TLS: total seedling length (cm), LR: main root length (cm), LS: shoot length (cm), NNS: number of normal seedlings and DMS: dry mass per seedlings (mg) at different crosses (C) and structured (S) in hybrids (H) and reciprocal (R).

In crosses 03 the hybrid was superior to reciprocal, obtaining 63.5% of emergency against 45.5% of reciprocal. The reciprocal of the 07 and 09 crosses were superior in emergence to the hybrids, with 86% to 47% and 95.5% to 82.5%, respectively. The highest emergency percentages were numerically reached by the hybrid and the reciprocal of crosses 01, with 100% and 99.50%, respectively.

In the case of crosses 03, it can be verified that the crossing originates from the commercial varieties BRS GA1 and BRS RC1, characterized as hybrids obtained by the population method, maintaining a genetic variability among plants, which would not cause inbreeding. But one possibility is that this germinative behavior was caused by the BRS RC1 variety, which also makes up crosses 06, where a similar germination rate is observed.

The observed emergency results corroborate with those reported by Baldissera et al. (2012) in their study with combinatorial capacity and reciprocal effect on agronomic traits of common bean. They concluded that evaluations of the reciprocal effect confirm the existence of difference when a plant is used as the male or female parent because there is the presence of cytoplasmic effect and nuclear genes of the female parent in the evaluated traits.

These results show the importance of the choice of female and male parents to perform crosses and obtain hybrid seeds of SPF with high germinative potential. As reported by Gomes et al. (2000) the correct choice of maternal and paternal parents is important in the formation of hybrid maize seeds with high germinative power.

As for the emergency speed index for crosses 03 and 10, the hybrids presented rates of 2.13 and 4.23, and reciprocals of 1.38 and 3.47, respectively. In crosses 04, 07 and 09, reciprocals were higher with rates of 4.13; 2.88 and 3.11, against 2.90; 1.63 and 2.64 of the hybrids, respectively. The hybrids that presented the highest rates were those of crosses 01, 02 and 10 (4.16, 4.41 and 4.23). Among reciprocals, the ones with the highest indexes were crosses 01, 02 and 04 (4.40, 4.31 and 4.13).

The greatest numerical value of the emergence speed index among all crosses and structures was obtained by the hybrid of crosses 02 (4.41). The rate obtained by the hybrid crosses 02 was higher than those found by Souto et al. (2017b), that studied germination and emergence speed index and found a value of 4.00 for the best treatment (genotype/hybrid 02). The high emergence speed index and quick emergence of the seedlings in a shorter period play an important role in genotype vigor and uniformity in establishing plants and seedlings production.

Macedo et al. (2013) verified that germination of papaya seeds did not occur between hybrids and reciprocals, on the other hand, the rate of emergence showed significant differences, evidencing delays in the germination time for those with higher values resulting in unevenness in the seedlings. According to Welter et al. (2011), it is important that the seeds exhibit rapid and homogeneous germination, obtaining uniform seedlings in a shorter time allowing the formation of continuously and uniformly seedlings.

Regarding the total length of seedlings, there was a difference between hybrids and reciprocals in crosses 06 and 10, with longer hybrids length. For the shoot length, there were no differences among the structures in any crossing. Hybrids and reciprocals differed in the number of normal seedlings at crosses 03, 07 and 08. Whereas for seedling dry matter there were only differences at crosses 10, in which the hybrid was superior to reciprocal.

In general, total seedling length, main root length, shoot length, and dry mass were not influenced by the type of structure or direction of the crosses. According to the results obtained in this experiments, it is important to study the structure of crosses, which will help future stages in breeding programs for the production of new commercial hybrids.

The reciprocal effects tell us which genotype is the most promising when used as the female or male parent for the trait under study. From these results, it can be inferred that there is a cytoplasmic effect in the female parent influencing the trait. In general, both the hybrids and the reciprocals of most crosses showed high germination.

Conclusions

In general, the hybrids and reciprocal showed similar values for the traits under this study. Four traits evaluated show interaction between crosses and structure such as weight of 100 seeds, emergence, emergence speed index and the number of normal seedlings, despite the influence of maternal effect on the expression of these traits in seeds of Sour Passion Fruit. Therefore, it is important to target the paternal and maternal genitor in order to obtain seeds with high germination potential in Sour Passion Fruit. The hybrid of crosses 10 stood out the best against the traits evaluated; for the reciprocal the greater prominence was obtained by crosses 01.

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