

Evaluation of the Ornamental Potential of Safflower (*Carthamus tinctorius* L.)

ABSTRACT

Aims: to evaluate the ornamental potential of two safflower genotypes (*Carthamus tinctorius* L.): ICA 73, ICA 193, grown under protected environment.

Place and Duration of Study: Department of Agronomy of Federal Rural University of Pernambuco, between March and May 2017.

Methodology: The methodology addressed evaluated the performance of the two genotypes, through three stages. The first stage was carried out in a completely randomized design, being evaluated: plant height; stem diameter; leaf dentin; spinescent margin of the leaves; number of branches; number of flower buds; spinescent margin of the bracts; flowering; and flower production. The second stage was conducted in a randomized complete block design in a factorial scheme, and the following variables were evaluated: plant height; stem diameter; number of branches; number of flower buds; and flower production. Finally, the third stage used a completely randomized design in a factorial scheme and evaluated the variables: number of flowers; number of flower buds; and post-harvest durability. The analysis of variance was performed using the F test at 5% of probability and, afterwards, the regression or comparison analysis of averages by the Tukey test at 5% of probability.

Results: The ICA 73 access showed plants with high flower production and the ICA 193 exhibited plants with weak or moderate spinescent margin of the leaves and bracts, besides good uniformity of the anthesis of the flowers.

Conclusion: Both accesses showed ornamental potential, demonstrating precocity, beauty and durability of the flowers. The density of one plant was the most favorable for pot plant and cut flower. The semi-open flowers harvest point was the best for maintaining the stem quality.

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Keywords: Floriculture. Precocity. Flowers. Potted Plant. Cut Flower Stems.

1. INTRODUCTION

Floriculture is a segment that stands out in the world, with significant growth, constituting an important source of income for several countries and promoting the development of productive poles. In this context, production is mainly intended for export to large consumer centers located in the European Union, the United States of America and more recently Asia and the Middle East [1,2].

In Brazil, in contrast to other developing countries, this sector has grown mainly towards the intern market [3]. With annual growth of around 8% a year, growing exports and significant increase in domestic consumption, the floriculture in the country became one of the most prominent segments in the agribusiness market, moving around R \$ 6.7 billion in 2016 [4].

27 Most of the market is supplied by plants from states in the Southeast of the country [5], while
28 other important Brazilian regions, where new floriculture poles emerge, end up with
29 difficulties to development, despite their natural aptitude for this sector [6].
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31 The floriculture consists of a dynamic sector with a constant search for new products that
32 meet the new trends. In this sense, safflower has great potential for this market. The
33 safflower (*Carthamus tinctorius*) belongs to the Asteraceae family, it is an herbaceous
34 annual plant, self-pollinated and capable of developing into various edaphoclimatic
35 conditions [7,8], tolerating low water availability and high temperatures [9].
36

37 The use of this herbaceous plant covers many possibilities and extends to practically every
38 part of the plant. Its seeds exploited part in the market, being present in food products [10],
39 cosmetics and also in the composition of drugs [11]. Safflower oil may also be intended for
40 biofuel production [12], and the bagasse used in animal feed supplements [13]. The flowers
41 allow the extraction of two dyes from their petals, a soluble and another hydrophilic [14], and
42 have ornamental potential as fresh or dried cut flower [15].
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44 The variability of the color, size and arrangement of the florets that the safflower possesses,
45 make the species very attractive to the floriculture market, being able to be used as
46 ornamental plants, cutting stems and confection of bouquets, with potential for planting in
47 gardens or pots and trade while fresh or when dry [16]. In Europe, the use of this
48 herbaceous plant in the flower market is common with specific cultivars for this purpose [17].
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50 Safflower cultivation in Brazil is still very limited and is restricted to basically attending to
51 some scientific research, moreover usually it covers only the production of oil, thus not
52 exploiting the ornamental potential. However, considering the importance that the floriculture
53 is taking in Brazilian agribusiness, the search and insertion of new products to expand and
54 meet market demand becomes a necessity and, in this context, investing in the potential of
55 this specie is a very promising strategy.
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57 The objective of this work was to evaluate the ornamental potential of two safflower
58 genotypes to pot plant and cut flower, cultivated in a protected environment, determining the
59 best density and harvest point.
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61 2. MATERIAL AND METHODS

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63 The safflower accesses (*Carthamus tinctorius*) ICA 73 and 193 used in the study were
64 imported by the Institute of Agricultural Sciences (ICA) in agreement with the Federal
65 University of Minas Gerais (UFMG) from germplasm banks of India and Ethiopia, which were
66 later transferred to the Plant Breeding Program of the Federal Rural University of
67 Pernambuco (UFRPE) to carry out this work.
68

69 The experiment was carried out in three stages under greenhouse conditions in the
70 Agronomy Department of the Federal Rural University of Pernambuco - UFRPE, Recife -
71 PE, whose geographical coordinates are 8°10'52"S latitude, 34°54'47" longitude and 2m
72 altitude.
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74 Sowing was done manually in pots with 5L capacity, filled with commercial Basaplant™
75 substrate, the depth of approximately three centimeters [18]. Irrigations were performed
76 manually and daily, approximately 300 ml per vase. No fertilization was performed.
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78 The first stage was carried out in a completely randomized design, with twenty repetitions.
79 The treatments were composed of the two safflower genotypes. Twenty vases were used for

80 each access (ICA 73 and ICA 193), where each vase represented an experimental unit,
81 totaling 40 parcels.

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83 The Emergency Velocity Index (EVI) was calculated according to the formula of [19]:

84 $EVI = \frac{\sum(E_n)}{Nn}$; Where: n = the number of normal seedlings recorded in the count "n";

85 Nn = number of days of sowing until the count "n". For this, the number of emerged plants,
86 with two open cotyledon leaves, was registered until the ninth day after sowing. The
87 percentage of germination was calculated after stabilization of the emergency, considering
88 the final number of emerged plants.

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90 The evaluations was carried out sixty days after sowing (DAS), based on the following
91 characteristics: Plant Height (PH (cm)) - performed with ruler and corresponding to the
92 measurement of the soil to the apex of the plant; Stem Diameter (SD (cm)) - measured with
93 a digital pachymeter in the base of the stem; Leaf Dentin (LD) - classified by scale of notes:
94 absent or weak (0); moderate (5); strong (10) [20] (Figure 1); **Spinescent Margin of the**
95 **Leaves (SML)** - graded by note scale: absent or weak (0); moderate (5); strong (10) [20]
96 (Figure 2); Number of Branches per plant (NB) - obtained by counting (Figure 3); **Number of**
97 **Flower Buds (NFB)** - obtained by counting the flower buds (*capitulum*); of the **Spinescent**
98 **Margin of the Bracts (SMB)** - graded by grading scale: absent or weak (0); moderate (5);
99 strong (10) [20] (Figure 4); Flowering (FI) - number of days from sowing to beginning of
100 flowering; Flower Production (FP) - obtained by counting open inflorescences.

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Figure 1. Leaf Dentin of Safflower: (A) Weak; (B) Moderate e (C) Strong.



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Figure 2. **Spinescent Margin of the Leaves** of Safflower: (A) Weak; (B) Moderate; (C) Strong.



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Figure 3. Safflower plants: (A) Little branched; (B) Very branched.



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Figure 4. Spinescent Margin of the Bracts of Safflower: (A) Strong; (B) Moderate; (C) Absent.

114 The second stage was conducted in a randomized block, in a 4 x 2 factorial scheme,
115 combining four plant densities per vase and two safflower access, distributed in 4 blocks.
116 Each block was composed of eight vases, each one corresponding to an experimental unit,
117 totalizing 32 experimental plots. The densities were evaluated referring to: four; three; two;
118 and one plant per vase.

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After reaching the phase of rosette (30 DAS), the apices of the central stem of the plants
were pruned through a single cut. Subsequently, 30 days after the procedure, the following
characteristics were evaluated: Plant height (PH (cm)); Stem Diameter (SD (cm)); Number of
Branches per plant (NB); Number of Flower Buds (NFB); Flower production (FP).

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The third stage used a completely randomized design, in a 3 x 2 factorial scheme, combining
three cutting points of the stems and two safflower accesses, using 4 repetitions. Twelve

127 vases were used for each genotype, wherein each vase received two seeds and
128 corresponded to one experimental unit, the cut-off points of the stems were: closed buds,
129 semi-open buds, and open buds. To stimulate the development of lateral buds the apices of
130 the central stem were pruned.

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132 The harvest point of the stems was done according to the respective treatments: Open
133 inflorescences, above 70% of the open florets; semi-open, 30 to 40% of open florets; and
134 closed, 5 to 15% of the open florets (Figure 5). The harvest point was determined based on
135 the inflorescences of each stem, and the cut was performed when half of the inflorescences
136 presented the percentage of open florets corresponding to the treatment. The stems were
137 cut in the basal portion, about 3 cm from the base of the plant. At laboratory, the flower stem
138 were evaluated from ornamental characteristics as follows: Number of inflorescences (NI)
139 Number of Close Buds (NCB); Later the flower stems were placed in containers with tap
140 water, leaving about 5 cm from the stem base submerged. The flower stems were discarded
141 when presented an unpleasant visual aspect, with flowers, leaves and stem darkened. The
142 Post-Harvest Durability (PHD) was consider the number of days from stem cutting to
143 discard.

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146 **Figure 5. Cut-off points: (a) Closed buds; (b) Semi-open buds; (c) Open buds.**

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149 For the analysis of variance, the effects of the treatments and the averages were considered
150 as fixed and treated according to the statistical model for the specific designs of each
151 experiment.

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153 Using the F test at the 5% probability level, were tested the significance of the mean squares
154 and posteriorly the means were submitted to polynomial regression analysis or comparison
155 of means by the Tukey test using the GENES program [21].

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157 Estimates of variance components and genetic parameters were obtained from the following

158 expressions: $\sigma_g^2 = \frac{QMG-QMR}{n}$, $h^2 = \frac{\sigma_g^2}{QMG/r}$, e $CV_g = \frac{100\sqrt{\sigma_g^2}}{\mu_n}$, for the genetic variance
159 among means, heritability coefficient and coefficient of genetic variation, respectively.

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162 3. RESULTS AND DISCUSSION

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164 The emergence of seedlings began 4 days after the sowing and continued for two days. The
165 accesses presented 80% and 90% of germination (% G) and 5.47 and 8.22 of Emergency
166 Velocity Index (EVI) for ICA 193 and ICA 73, respectively.

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168 Significant differences were observed between the accesses evaluated at the 5% level by
169 the F test for the analyzed characteristics, except for the diameter of the stem, evidencing
170 the existence of genetic variability (Table 1).

171

172 According to [22], the plants are classified as ornamental when they present characteristics
173 that arouse attention and interest, from their aesthetic particularities, referring to the color
174 and shape of leaves and flowers, phenological aspects, among others. Taking these
175 characteristics into consideration, the ICA 73 presented plants with the highest number of
176 branches (9.15), a high number of buds (15.9) and, mainly, high flower production (14.3). On
177 the other hand, it exhibited strong spinescent margin of the leaves and bracts (9.25). On the
178 other hand, ICA 193 access presented the most favorable points to the low and moderate
179 spinescent margin of the leaves and bracts (2.39 and 3.36, respectively). However, showed
180 low branching (5.25) and consequently, lower number of buds and flower production (7.65
181 and 6.95, respectively) (Table 2).

182

183 According to [23], the leaves and bracts margins of safflower plants are peculiarly
184 spinescent, however the vehemence with which this characteristic is expressed in the plant
185 varies according to the different genotypes, thus allowing the selection and development of
186 varieties that exhibit a weak or moderate character expression, offering attractive materials
187 to the floriculture market.

188

UNDER PEER REVIEW

189 **Table 1. Summary of variances analysis and genetic parameters estimates for Plant Height (PH), Stem Diameter (SD), Leaf Dentin**
 190 **(LD), Spinescent Margin of the Leaves (SML), Number of Branches (NB), Number of Flower Buds (NFB), Spinescent Margin of the**
 191 **Bracts (SMB), Flowering (FI), and Flower Production (FP), Recife, 2017.**

SV	DF	MS								
		PH (cm)	SD (cm)	LD	SML	NB	NFB	SMB	FI	FP
Accesses	1	2822.4	0.006	30.625	122.5	152.1	680.62	90.0	198.02	540.22
Residual	38	6665.2	0.022	5.62	15.20	8.90	36.75	13.35	22.31	28.18
F		16.09**	0.29 ^{ns}	5.44*	8.06**	17.08**	18.52**	6.74*	8.87**	19.16**
Mean		68.1	0.98	4.12	7.5	7.2	11.77	7.75	56.52	10.62
CV		19.45	15.06	57.50	51.98	41.44	51.48	47.15	8.36	49.97
σ^2_g		132.35		1.25	5.36	7.16	34.03	3.83	8.78	25.60
H^2_g		93.78		81.63	87.60	94.15	94.60	85.16	88.73	94.78
CV_g		16.89		27.10	30.88	37.17	48.19	25.26	28.25	47.62
CV_g/CV_e		0.87		0.47	0.59	0.90	0.94	0.53	5.24	0.95

* and ** significant at the 5% and 1% levels, respectively, of the probability by the F test and "ns" not significant by the F test

192 **Table 2 - Average of Plant Height (PH), Stem Diameter (SD), Leaf Dentin (LD), Spinescent Margin of the Leaves (SML), Number of**
 193 **Branches (NB), Number of Flower Buds (NFB), Spinescent Margin of the Bracts (SMB), Flowering (FI), and Flower Production (FP),**
 194 **Recife, 2017.**

Accesses	PH (cm)	SD (cm)	LD	SML	NB	NFB	SMB	FI	FP
ICA 73	59.7b	9.99a	5.0a	9.25a	9.15a	15.9a	9.25a	58.7a	14.3a
ICA 193	76.5a	9.74a	3.25b	2.39b	5.25b	7.65b	3.36b	54.3b	6.95b

197 *Means followed by the same letter do not differ by Tukey test at 5%.

198 Plants with spines have less acceptance in the market, by virtue of limiting the touch, due to
199 the possibility of promoting scratches in the skin. In this context, ICA 193 stands out for
200 having naturally weak or moderate spinescent margins, both in the leaves and in the bracts,
201 presenting viability for insertion in the market of cut flowers without resistance to acceptance.
202 In contrast, access ICA 73 needs to be submitted to breeding programs in order to
203 circumvent this limitation for its use in floriculture.

204
205 Both accesses presented precocity of flowering, and ICA 73 presented a subtle highlight in
206 relation to this phenological stage, starting its flowering about 59 DAS, while the ICA 193
207 access began about 54 DAS. According to [24], this phase starts between 60 and 100 days
208 after sowing and confirms, therefore, the precocity of the materials evaluated in this work
209 (Table 2).

210
211 No early commercial material of *Carthamus tinctorius* intended for the ornamental market is
212 reported, in addition, it is possible to notice a certain difficulty in the development of cultivars
213 of this species that present attributes of ornamental interest and initiate this phenological
214 stage early [15]. Less late varieties, commonly used, show beginning of flowering only 80
215 days after sowing [25,26]. In this sense, the accesses under study have a scarce and
216 desired characteristic, offering a further differential to include these in commerce, not only
217 facilitating acceptance but demonstrating competitiveness with products already available.

218
219 Regarding plant height, ICA 73 showed lower heights than ICA 193, referring to 59.7 cm and
220 76.5 cm, respectively (Table 2). Considering also the use for cutting stem, according to [15],
221 the stem length of products with superior quality must present between 70 cm and 80 cm,
222 however, there are already commercial safflower varieties specific to the ornamental market
223 with stems from 60 cm [25]. In this way, the values demonstrated by the accesses of this
224 research, fit within the allowed for both sides.

225
226 As to leaf dentin, ICA 73 presented moderate intensity (5.0) and weak to moderate ICA 193
227 (3.25) (Table 2). In order to make arrangements, the margin of the leaf does not have a fixed
228 pattern, since even the most unusual can contribute to creative and decorative
229 combinations, including being something very desired to compose bouquets base [27].

230
231 During the experiment, the plants were affected by pathogens and pests, since no chemical
232 control was performed. From the symptoms and a previous microscopic analysis, the
233 presence of *Cercospora carthami* and aphid (aphis) was observed (Figures 6a and 6b).
234 However, the inflorescences were not directly affected and the characteristics of interest
235 could be effectively evaluated. [12] reported that, safflower is the target of many pathogens,
236 including fungi, bacteria and viruses, but the first group cited is the most prominent.
237 *Cercospora carthami* is one of the fungi that commonly affect the culture, causing foliar
238 damage. Among the pests, aphids are said to cause the most recurrent damages, however
239 they are less worrisome than diseases [28].

240
241 The summary of the analysis of variance for the second experiment and the estimation of the
242 main genetic parameters for the agronomic and ornamental characters evaluated in the two
243 safflower accesses are organized in Table 3. According to the results, it is possible to
244 observe a significant difference between the accesses at the level of 5% by the F test for the
245 characteristics analyzed.



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Figure 6. Safflower plants: (A) Pest attack (aphids); (B) Leaf disease (*Cercospora carthami*).

Table 3. Summary of variances analysis and genetic parameters estimates for Plant Height (PH), Stem Diameter (SD), Number of Branches (NB), Number of Flower Buds (NFB), and Flower Production (FP), Recife, 2017.

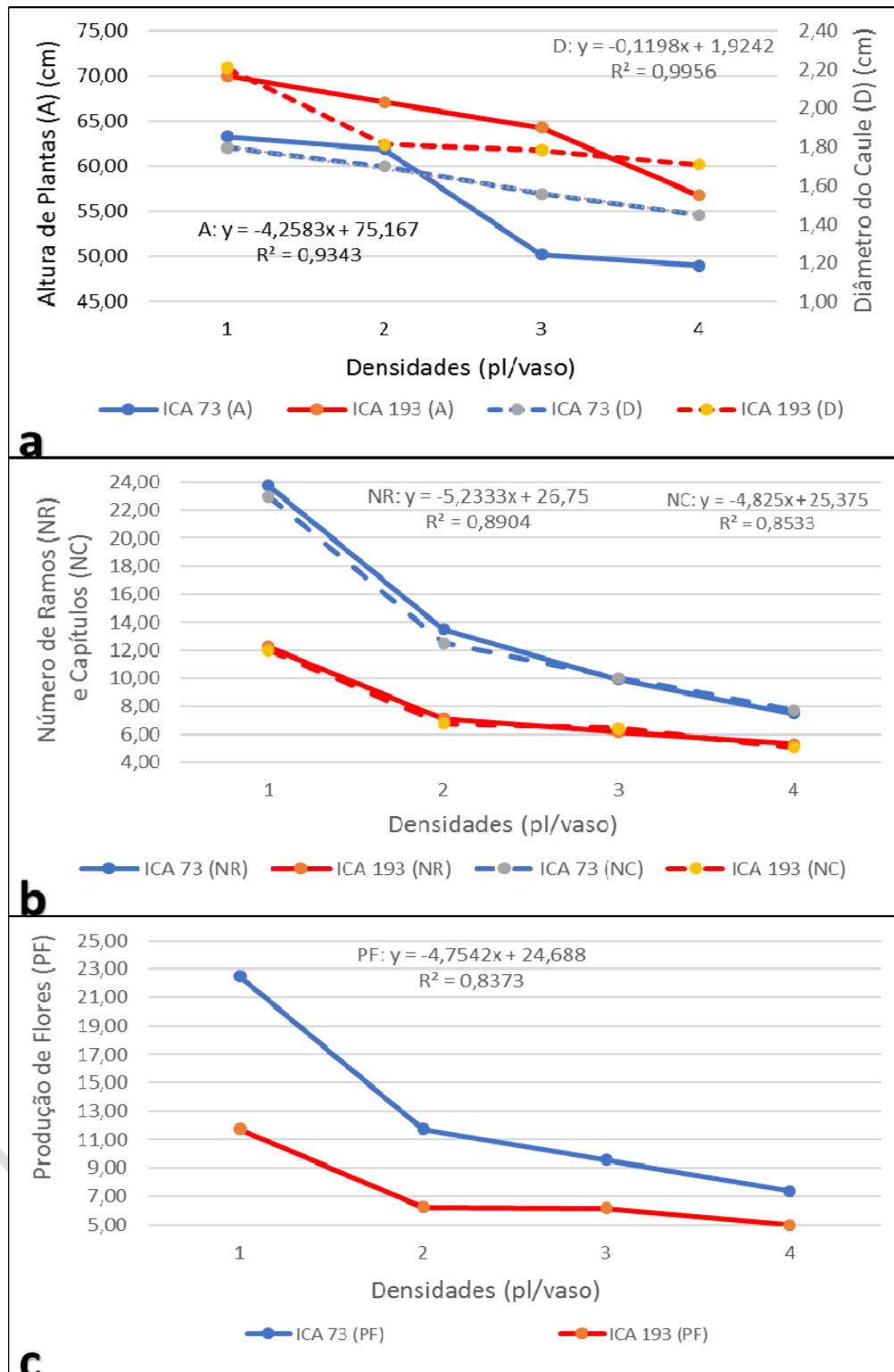
SV	DF	MS				
		PH (cm)	SD (cm)	NB	NFB	PF
Blocks	3	36.68	0.03	5.54	7.10	5.78
Accesses	1	570.94*	0.51*	283.52**	264.97**	242.91**
Densities	3	325.76*	0.27*	210.51**	191.36**	188.82**
AccessesxDensities	3	30.41 ^{ns}	0.04 ^{ns}	33.31**	27.76**	27.78**
Residual	21	79.10	0.05	2.90	3.58	2.93
Mean		60.30	1.75	10.69	10.43	10.05
CV		14.74	12.61	15.94	18.14	17.04
σ^2_g		30.74	0.03	17.54	16.34	15.00
H ²		86.15	90.46	98.97	68.65	98.79
CV _g		9.19	9.71	39.17	38.73	38.55
CV _g /CV _e		0.62	0.77	2.46	2.13	2.26

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* and ** significant at the 5% and 1% levels, respectively, of the probability by the F test and "ns" not significant by the F test.

Figure 7 graphically shows the behavior of the accesses as a function of the different densities of plants per vase, as well as the equations and coefficient of determination (R²) that best fit the variables studied, according to the regression analysis. All variables can be explained by the linear equation of the 1st degree, with R² values higher than 0.80.

Plant height and stem diameter were inversely proportional to plant density per vase, decreasing as the number of plants increased (Figure 7a). The diameter is an important feature because it is related to rigidity and quality of the stem, since low densities can lead to flexibility and breakage [29]. Pruning did not limit the final length of the plants, which reached values characteristic of the species.



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Figure 7. Plant Height (PH), Stem Diameter (SD), Number of Branches (NB), Number of Flower Buds (NFB), and Flower Production (FP) of ICA 73 and ICA 193 safflower accessions according to four plant densities per pot.

270 The highest values of height and diameter were reached by ICA 193 access, with values
 271 ranging from 56.75 to 70.00, and 1.71 to 2.21 (Figure 7a). In the first case, the values
 272 extrapolate the recommendation of [30] for use in vases, but is suitable for employment in
 273 other areas of social recreation. In this sense, there are already commercial safflower
 274 varieties destined for the ornamental market with heights between 60 and 80 cm, such as
 275 Orange Granade, which is highly prized for beautifying gardens [25]. In contrast, ICA 73
 276 exhibited the smallest values of height and diameter, ranging from 49.00 to 63.25 and 1.44
 277 and 1.80 (Figure 2a). Despite the low diameter values, the stems showed to be well lignified
 278 and no breaks were observed.

279
 280 The decrease due to the increase in the number of plants per vase for number of branches,
 281 buds and flower production was also observed (Figure 7b and 7c) and is in agreement with
 282 the one verified by [31], that in its work with other safflower genotypes evidenced a linear
 283 reduction proportional to the increase of the density. This result is probably linked to
 284 competition between plants for nutrients, water and light, limiting their development [29]. For
 285 use in potted plants or gardens, plants with more branches, provide a aerial part more
 286 voluminous and visually pleasing. Access ICA 73, presented the highest values for these
 287 characteristics and the best density for both genotypes, refers to 1 plant per vase.

288
 289 The high number of branches acts negatively on the uniformity of the opening of the flowers,
 290 due to the different flowering rates of the buds [29]. For ornamental plants destined to
 291 gardens, vases or other leisure areas, this particularity becomes attractive, because it makes
 292 possible that the prestige of the flowers can be realized by a greater period of time, since
 293 while the first flowers are close to senescence, others will still be at the beginning of the
 294 anthesis. On the other hand, this factor is not attractive for cutting stems.

295
 296 In Table 4, the analysis of variance of the third experiment and the estimation of the main
 297 genetic parameters for characters of ornamental importance evaluated in the two accesses
 298 of safflower. The results show a significant difference between the accesses at the 5% level
 299 by the F test for the characteristics analyzed. Table 5 shows the means of the variables that
 300 were submitted to the Tukey test, depending on the treatment factors: accesses and cut-off
 301 points.

302
 303 **Table 4. Summary of variances analysis and genetic parameters estimates for Number**
 304 **of inflorescences (NI), Number of Close Buds (NCB), Post-Harvest Durability (PHD),**
 305 **Recife, 2017.**

SV	DF	MS		
		NI	NCB	PHD
Accesses	1	54.0**	84.37**	88.17**
Cut-off Point	2	26.54**	22.79**	77.17**
AccessesxCut-off	2	13.62**	15.87**	4.67 ^{ns}
Residual	18	1.17	1.12	1.33
Mean		5.33	3.21	10.58
CV		20.03	33.06	10.91
σ^2_g		4.40	6.94	7.24
H ²		97.84	98.67	98.49
CV _g		39.34	82.10	25.42
CV _g /CV _e		1.94	2.48	2.33

306 * and ** significant at the 5% and 1% levels, respectively, of the probability by the F
 307 test and "ns" not significant by the F test.

308 The maturity of the flowers is a very decisive characteristic on the quality of the product and
 309 makes it impossible in most cases to perform a mechanized harvest [15], justifying the
 310 importance of defining the best moment for cutting the stems, as far as the anthesis of
 311 flowers is concerned. Other important information that should be considered refers to the
 312 fact that the central flower opens days before the lateral flowers, about one week, leading to
 313 visual depreciation when the other flowers are opening [32], for this reason the pinch was
 314 performed, stimulating the anther of the lateral flowers in a more uniform way.

315
 316 The number of inflorescences, number of close buds and post-harvest durability should be
 317 analyzed together and as a function of the cut-off point, allowing to establish the most
 318 appropriate combination for quality of the final product.

319
 320 The ICA 73 had a higher average number of inflorescences (10.25) and a lower number of
 321 close buds (1.75) for the cut-off point when buds were open, however, in this same
 322 treatment the lower post-harvest durability of the stems was obtained (4.25), making it
 323 impossible to cut stems of this material at this maturation level, since it does not meet an
 324 adequate number of days of product life (Table 5). At the point of semi-open buds, the
 325 number of inflorescences (5.75) was reduced by half and the number of close buds
 326 increased (6.00), showing a nearly 1: 1 ratio between flowers and buds, indicating little
 327 uniformity of flower anthesis and opening of a few buds after cutting, but exhibited longer
 328 flower durability (11.00) (Table 5). Finally, at the point of closed buds the number of
 329 inflorescences reduced even more, evidencing that some of the heads did not even develop
 330 buds and the low number of close buds also confirms this hypothesis, however, the durability
 331 of the stems was equivalent to the cutting treatment with the semi-open flowers.

332
 333 **Table 5 - Average of Number of Inflorescences (NI); Number of Close Buds (NCB);**
 334 **Post-Harvest Durability (PHD), Recife, 2017.**

	Variables					
	NI		NCB		PHD	
	ICA 73	ICA 193	ICA 73	ICA 193	ICA 73	ICA 193
Open Buds	10.25Aa	4.25Ba	1.75Ac	1.25Bc	4.25Bb	9.75Ab
Semi-open Buds	5.75Ab	4.50Ba	6.00Ab	0.50Bb	11.00Ba	13.50Aa
Closed Buds	4.50Ab	2.75Bb	7.50Aa	2.25Ba	10.75Ba	14.25Aa

335 **Means followed by the same lower letters in column and capital letters on the lines*
 336 *do not differ significantly by the Tukey test at 5%.*

337
 338 ICA 193 presented a lower average number of inflorescences when compared to ICA 73 at
 339 all cut-off points, however, it also exhibited a lower number of close buds, indicating a
 340 greater uniformity of flower anthesis. At the cut-off point with open buds, exhibited the
 341 second highest value of inflorescences (4.25), according to lower flower buds values (1.25)
 342 and lower post-harvest durability of the stems (9.75), however, this useful life is already
 343 acceptable to the market (Table 5). For the cut-off point with semi-open buds, it presented
 344 the highest number of inflorescences (4.50), although it does not differ statistically from the
 345 previous treatment for this characteristic, smaller number of close buds (0.50) and second
 346 highest number of days of stem durability (13.50). Finally, at the cut-off point with closed
 347 buds, the lowest number of inflorescences (2.75) and the highest number of floral buds
 348 (2.25) were observed, evidencing the difficulty of developing the buds after cutting the
 349 stems, also presented the greatest number of days of durability of the stems (14.25), but did
 350 not differ statistically from the previous treatment for this characteristic.

351
 352 According to [32], the most favorable cutting stage of the stems corresponds to the period in
 353 which 20% to 30% of the central florets opened, which is equivalent to the cut-off point

354 denominated in this work as semi-open buds, allowing the others to open in the hands of the
355 consumer, extending the useful life of the product. In agreement with this affirmation, it is
356 observed that ICA 193 presented the best combination of factors for this cut-off point,
357 presenting a higher number of inflorescences, lower number of close buds and greater post-
358 harvest durability. The same observation can be raised for ICA 73, but with some
359 reservations, such as the performance of a removal of the secondary and tertiary branches,
360 improving the aesthetics of the product, since despite an adequate number of inflorescences
361 and stem durability, it presented high number of close buds, or search for improvements of
362 this characteristic through an improvement program.

363
364 The flowers produced by both genotypes showed a yellow color at the beginning of the
365 anthesis, changing to orange shades soon after and presented a very attractive visual
366 aspect, with abundant beauty while fresh and even after a period of drought, offering
367 potential for introduction into the Brazilian flower market, contributing to the supply of news
368 for the sector and the consumer (Figure 8a and 8b). According to [23], the characteristics of
369 greater importance and influence on the ornamental value of safflower are attributed to the
370 color of the flowers, where the oranges and yellows stand out, along with the weak
371 spinescent margin of the leaves and bracts.
372



373
374 **Figure 8. (A) Bouquet of stems after cutting; (B) Change the color of the flower.**
375

376 The evaluated characteristics presented high estimates of the genetic parameters of
377 heritability and ratio between the coefficients of genetic and experimental variation, a very
378 favorable point in breeding programs, since it indicates in a general way that these
379 characters can be easily improved through classic methods [33] and provide favorable
380 conditions for realization of selection, allowing to obtain high genetic gain within the first
381 cycles [34].
382

383 Considering the differences evidenced between the genotypes, together with the
384 completeness they demonstrate for characteristics of ornamental interest, these genotypes
385 suggest potential for inclusion in an improvement program, in order to obtain a material that
386 groups the positive characteristics presented in both accesses. [35] point out that one of the
387 criteria for success in crossbreeding depends on the divergence between the parents,
388 parallel to the superior performance they present referring to the characteristics of interest of
389 the breeder.
390

391 **4. CONCLUSION**

392

393 The accesses ICA 73 and ICA 193 have ornamental potential, coupled with the precocity,
394 beauty and durability of their flowers. For plant vase, the best density for cultivation refers to
395 one plant per vase, allowing better expression of the plants' ornamental potential. The
396 harvest point with semi-open buds was the best for obtaining stems with greater post-
397 harvest durability.

398

399

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