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Field trial survey and breeder perceptions to select between ornamental *Glandularia* hybrids

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Abstract

The aims of the paper are to characterize the ornamental bedding behaviour of selected *Glandularia* materials, to evaluate breeder and public preferences (PP) of new potential ornamental plants to be introduced in the market and to obtain a ranking with the best-selected materials. After hybrids characterizations through different traits of ornamental interest, a survey was conducted to identify the breeder and PP separately but also with an integrated index. The indices were applied to systematize bedding data considering breeder and public aesthetic preferences using persistent (12-months plants) and new (3-months plants) materials. Similarities were found in the breeder and PP for new materials. The perception of a similar aesthetic value by the breeder and the public was reflected in the scores assigned to *Glandularia* hybrids materials. For persistent materials, breeder and public perceptions presented some differences that are interesting to be considered at the moment to introduce new ornamental plants into the market.

Keywords: bedding, improvement, market, native plants, public, survey

Introduction

The ecological and identity crises experienced by citizens of modern cities have pushed garden designers to seek inspiration in indigenous landscapes. The native component of biodiversity was appreciated as one of the most important 'tools' for urban ecological and cultural identity (Mumaw *et al*., 2018). Moreover, climate change will certainly affect hydrological regimes (Gautam and Singh, 2015) and contributes to the surface warning with extreme temperatures at extended urbanizations (Gallo and Owen, 1999; Kalnay and Cai, 2003). Gardening with native plants is becoming more popular in terms of sustainable landscaping providing some ecosystem services (Phondani *et al*., 2016), brings in consequence new challenges and increasingly demand native plants to complement their urban landscapes.

Hundreds of species of many botanical families used intensively in commercial floriculture and garden plants and traded commercially as ornamentals (Heywood, 2001). The success of the new floricultural products in the market can be increased if the ornamental desirable traits were determined by specific criteria (Stumpf *et al*., 2007), such as the morphological characteristics of the plant, as regard to its novelty or aesthetic value (Tognon and Cuquel, 2016). A better understanding of consumers' preferences for native plants, their attitudes toward bringing a more naturalistic landscape design and the assessment of their purchase behaviour may allow a better characterization of the market for producers of native plants (Nils Peterson *et al*., 2012; Alam *et al*., 2017). Successful breeding of potential

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Table 1. Hybrids coding, parents and material type of *Glandularia* (12 M: twelve months plants; 3 M: three-month plants)

Lots	Hybrid	Parents	Material type
1	UCC#113122009	*G. glandulifera* × *G. peruviana*	12 M
2	UCC#615122009	*G. glandulifera* × *G. peruviana*	12 M
3	UCC#815122009	*G. glandulifera* × *G. peruviana*	12 M
4	UCC#1520122009	*G. glandulifera* × *G. platensis*	12 M
5	UCC#2105012010	UCC20081107F4 × UCC20081107F3	12 M
6	UCC#2606102010	*G. glandulifera* × *G. peruviana*	12 M
7	UCC#2708122010	*G. glandulifera* × *G. peruviana*	12 M
8	UCC#3721122010	*G. peruviana* × *G. platensis*	12 M
9	UCC#4029122010	*G. glandulifera* × *G. peruviana*	12 M
10	UCC#4605012010	*G. peruviana* × *G. glandulifera*	12 M
11	UCC#1120122009	*G. glandulifera* × *G. peruviana*	3 M
12	UCC#2210012010	UCC20081031E1 × UCC20081107F3	3 M
13	UCC#5701112011	*G. glandulifera* × UCC#615122009	3 M
14	UCC#5922102011	*G. glandulifera* × UCC#615122009	3 M
15	UCC#6022102011	*G. glandulifera* × UCC#113122009	3 M
16	UCC#6122102011	*G. glandulifera* × UCC#615122009	3 M
17	UCC#6210032012	*G. glandulifera* × UCC#1520122009	3 M
18	UCC#6525032012	UCC#113122009 × UCC#615122009	3 M

ornamental hybrids; it also includes commercial production and marketing (Kleynhans and Hancke, 2002), thus, the aim of breeders is to produce improved plants (Rees, 1992) and obtain better materials for the producers and the consumers (Barbosa Silva Botelho *et al.*, 2015). For that, the measurement and analysis of public preferences (PP) of native floricultural cultivars (Villanova *et al.*, 2007), may express an agreement of potential consumers to accept native plants (Nils Peterson *et al.*, 2012).

Glandularia (Verbenaceae) with 33 native species from Argentina (Peralta and Múlgura, 2011), comprises erect, semi-erect and decumbent plants with flowers of varied colours, gathered in contracted clusters striking for their size, colour and fragrance, with prolonged periods of flowering (Botta, 1993). This genus presents species with aesthetic and ornamental characters of interest (Stancanelli *et al.*, 2010), which can survive under unfavourable climatic conditions. Henson *et al.* (2006), working with a hybrid between *Glandularia tenuisecta* and *G. tenera* ('Imagination'), evaluated their ornamental performance and concluded that this genus is drought resistant as *Petunia*. McKenney *et al.* (2007) recommended 'Raider Amethyst' Prairie Verbena [*Glandularia bipinnatifida* (Nutt.) Nutt.] to use in water-conserving landscapes with low maintenance plantings, in addition to its characteristics of compactness, great branching and the bright colours of the flowers. From 2006, we have developed ornamental hybrids from native populations of *Glandularia glandulifera*, *G. peruviana* and *G. platensis* through a breeding program (Imhof, 2013). For that, the objectives of this study were: (1) to characterize the ornamental bedding performance of selected *Glandularia* hybrids; (2) to evaluate the PP of *Glandularia* hybrids through a specialized audience and (3) to obtain a ranking of selected *Glandularia* materials using an index that integrates the perception of the breeder and the preferences of the potential consumers.

Material and methods

Populations of *G. glandulifera*, *G. peruviana* and *G. platensis* from our breeding programme were used. The collection was cultivated under greenhouse conditions at the Catholic University of Córdoba, Argentina (31.66°S, 64.43° W). Hybrids from partial diallel crosses were obtained for the assessment (Imhof *et al.*, 2013). Measurements were obtained from plants transplanted 3 months before data were collected (called 'three-month plants' materials, hereafter 3 M) and on plants that have 12 months in bedding conditions before data were collected (called 'twelve-month plants' materials, hereafter 12 M), as it can be seen in Table 1.

Breeder characterization

Ornamental bedding hybrids were characterized in plots simulating real landscape situations. Aesthetic characters appreciated by specialized public or selected by breeders

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were measured. Hybrids were propagated asexually by 3 cm stem cuttings and cultivated in a mixture of peat and perlite (3:1). Rooted cuttings of each hybrid were cultivated to full bloom in plastic pots (12.5 cm in diameter) on a substrate consisting of soil, compost and perlite (1:1:1). Afterwards, these plant materials were transplanted to outdoor growing conditions, during spring (southern hemisphere) September and October for new materials (3 M) and persistent materials (12 M), respectively. Nine plants were planted in each plot spaced 30 cm apart and cultivated to full bloom. The following aesthetic characters were measured: coverage area (Ca; %) (percentage of surface covered by the plant in a bedding), number of branches (Nb) (Nb and sub-branches per plant) and number of inflorescences (Ni) per plant. Variables comparing hybrids performance were analysed separately through the analysis of multivariate profiles (Di Rienzo *et al.*, 2011). Using these variables an index was constructed, the ornamental fitness of bedding index (OBFI) with the same relative weight for each of them: OBFI = (0.33 × Ca + 0.33 × Nb + 0.33 × Ni).

Data of the measurements for each trait and the OBFI index for 3 and 12 M materials are the following:

For 3 M type, the periods for measurements were: D1, 3 months after planting; D2, 15 d after first measurement and D3, 60 d after the first measurement. The measured characters are,

- Ca, %: with the obtained valued of 30–50% (0 in the weight per category); between 50 and 70% (0.5 in the weight per category) and more than 70% (1 in the weight per category).
- Nb: with the obtained valued of less than 30 (0 in the weight per category); between 30 and 60 (0.4 in the weight per category); 60–90 (0.8 in the weight per category) and more than 90 (1 in the weight per category).
- Number of inflorescence (Ni): with the obtained valued less than 30 (0 in the weight per category); between 30 and 50 (0.5 in the weight per category); more than 50 (1 in the weight per category).

For 12 M type,, the periods for measurements were: D1, 360 d after planting; D2, 15 d after the first measurement and D3, 60 d after the first measurement. The measured characters are,

- Ca, %: with the obtained valued of 60–70% (0 in the weight per category); 71–80% (0.5 in the weight per category) and more than 80% (1 in the weight per category).
- Nb: with the obtained valued of less than 50 (0 in the weight per category); between 50 and 90 (0.5 in the weight per category) and more than 90 (1 in the weight per category).
- Number of inflorescence (Ni): with the obtained valued less than 50 (0 in the weight per category); between 50 and 90 (0.4 in the weight per category); between 90 and 130 (0.8 in the weight per category) and more than 130 (1 in the weight per category).

Measurements were taken during the spring for 3 and 12 M materials. First data set for 3 M plants was taken 3 months after the planting day (d 0), and the other measurements were obtained at 15 and 60 d after the first one; for 12 M materials, the first data set was taken 360 days after the planting day (d 0), and the other measurements were obtained at 15 and 60 d after the first one. The average value of these three measurements for each material was used to calculate the index for 3 and 12 M types.

PP: The field trial survey

Since 2006, every year the Catholic University of Córdoba opens its field trials to the specialized public. Attendees were members of the floriculture sector of the province of Córdoba, agronomic engineers, landscapers, architects, biologists, nurserymen and wholesalers, among others. On the eighth exhibition (11 December 2013), 27 individuals were asked to participate in a survey to evaluate the materials. Hybrid materials of different planting date (3 and 12 M) were evaluated. Hybrids were presented to the specialized public into numbered plots (Fig. S1). Participants were asked to indicate individually the top five materials with ornamental aesthetic value through a six-point scale (0 = no vote and 1–5 for 1 = lowest and 5 = highest score for each feature) taking into account the following plant traits of each hybrid plot: number of flowers, plant architecture and flower colour. The specialized observer had to select five (5) materials weighting each of them by the number of flowers and colour of the inflorescences, and determine if the plant architecture seemed appropriate for bedding purposes. Then, hybrids were classified into four categories according to the number of votes that they received: between 10 and 14 (high acceptance), 4–9 (medium acceptance), 1–3 (low acceptance) or 0 (any attention). The weights in the index for the different characters and hybrids were obtained considering data from PP as follows: 0 (no votes), 0.4 (low acceptance), 0.6 (medium) and 1 (high). The values of the PP for the different hybrids and traits were included for the calculation of the integrated index (IOBFI) to compare hybrids.

IOBFI: breeder characterization and PP vision together

The IOBFI was built using the variables characterized by the breeder and the value obtained from the general and qualitative evaluation of the public (PP through voting different hybrids as was explained above for new and

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persistent materials (3 and 12 M respectively): IOBFI = [0.5 × OBFI] + [(0.5 × PP)]. Table 2 shows the value of the index (OBFI), the value given by the public (PP) and the resulting value of the integrated index for each hybrid. New and persistent materials were ordered according to the IOBFI value.

Results

Breeder characterization

The ornamental breeder perception of the hybrids was analysed quantitatively through three variables (Figs. 1–3). The materials were divided and were presented into four groups, two for 12 M materials (1–5 and 6–10; see Table 1 for hybrid coding) and two for 3 M materials (11–14 and 15–18; see Table 1 for hybrid coding) for a better visualization of the results. The best performance for 12 M materials according to the Nb was registered for lots 4, 5, 9 and 10 from Fig. 1(a) and (b), respectively (Fig. 1(a) and (b)) and for lots 14, 12, 17 and 18, in that order, that correspond to 3 M materials (Fig. 1(c) and (d)). The better performance for 12 M materials according to the Ni was registered for all lots, (Fig. 2(a) and (b); except for lots 1 and 10 which presented values >50 inflorescences), and for lots 11, 12, 14 and 17 that correspond to 3 M materials (Fig. 2(c) and (d)). The better performance for 12 M materials according to plant coverage (Ca) was registered for lots 4, 2, 3, 9 and 10 (Fig. 3(a) and (b)) and for lots 12, 13 to 17 that correspond to 3 M materials (Fig. 3(c) and (d)).

PP: the field trial survey

The categorization of public votes from the field trial survey (high, medium and low acceptance) can be seen in Table 3. Only two lots showed high acceptance from the public (lots 5 and 6) or medium acceptance (2 and 9). Lots 3, 7, 8, 10, 12, 13, 16 and 17 presented a low degree of acceptance from the public and the rest of the lots were not voted (Lots 4, 11, 14, 15 and 18).

IOBFI: breeder and public characterization together

Table 3 shows the values obtained for the OBFI, PP and IOBFI for new and persistent materials (3 M and 12 M plants), respectively. Hybrids were ordered based on the value of the IOBFI, namely, according to their performance in bedding and the degree of both the public and breeder acceptance. This arrangement allowed us to find the hybrids located in the highest performance for 12 M materials, lots 6 (first place), 5 (second), 9 (third), 2 and 10 (shared the fourth place), and 3 (fifth place). For 3 M materials, the best placed were lots 17, 13 and 12 with the eighth, ninth and tenth place. For 12 M materials, only the first two places (lots 6 and 5) coincided with the valuation given by the breeder (0.849 and 0.806) and the public (1 and 1), respectively. For the rest of 12 M materials, the breeder had a better appreciation than the public, showing differences in this sense. In the case of 3 M materials, the valuation of the materials was similar.

Figure S1 shows the plots of the three best 12 M materials (with the best value of IOFBI, Lot 6, 5 and 9) and the best 3 M material (lot 17).

On the other hand, the differences in the scoring for 12 M plants may be due because potential consumers generally base their decisions on a global perception of the product (i.e., it is not possible to distinguish individual 12 M plants), rather just one or few characteristics of the whole group of 12 M plants (Behe *et al*., 1999). Asking potential consumers how much they like only one aspect of each material (e.g., flower colour), it may not be the best indicator of their overall preference for the product, or of the importance of a single trait in the purchase decision (Behe *et al*., 1999). Thus, the results of this study could be an initial approximation to know people preferences of potential ornamental *Glandularia* hybrids. Moreover, preferences on some selected materials could be appreciated differentially according to their developmental stage.

Discussion

Breeder characterization

Gardening is considered a positive activity with psychological and social benefits (Mumaw *et al*., 2018). Breeders, wholesalers, retailers and consumers of ornamental plants traditionally looked for products that represent new trends (Stumpf *et al*., 2008). Frequently, these new products are initially evaluated for landscaping through different traits like plant architecture, colour, texture, size or flowering phenology (Stumpf *et al*., 2012). Stumpf *et al*. (2007) informed about the complexity of identifying new ornamental plants, as the perception of aesthetic attributes, which are dictated by subjective and personal feelings. Furthermore, the beauty of a plant is not the only criterion necessary to make it commercially successful. At the selection stage of the better *Glandularia* hybrids for ornamental purposes, some aesthetic traits, as Ca, Nb and Ni, were chosen to evaluate their performance in landscaping. As McKenney *et al*. (2007) observed, prairie *Glandularia* as day-light length increases, internode length increases and the plants attain a more upright habit. In our *Glandularia* hybrids, the Nb and Ca were increased over the developing period as day-light length increases. Lots 4, 9, 14 and 17 were the most promising ones to meet

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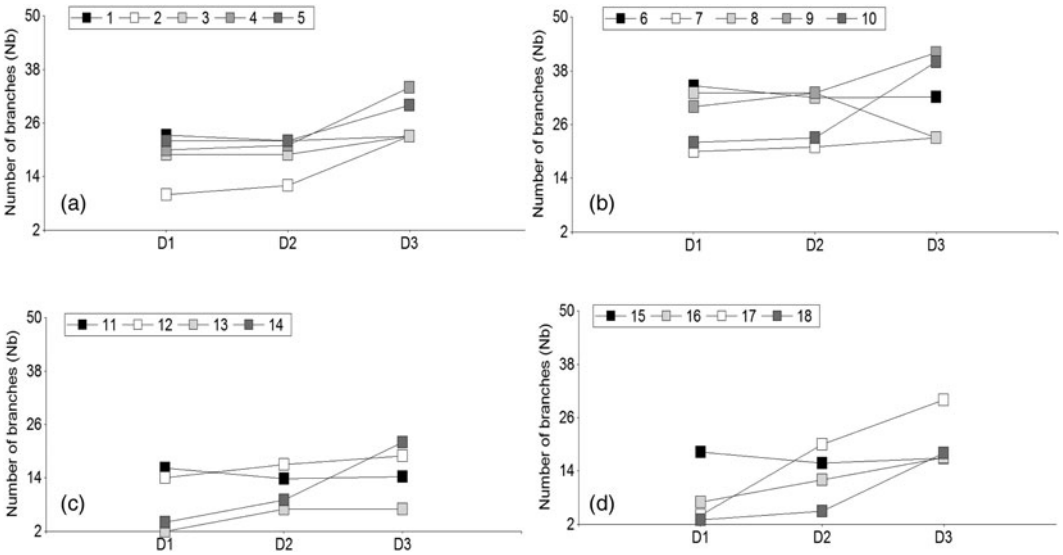

Fig. 1. Changes in number of branches throughout the growing season for the different *Glandularia* hybrid materials in process of improvement tested in landscape conditions: Materials were divided into four figures to better visualize their differences: (a) Five lots of the 12 M materials (Lots 1–5); (b) Five lots of the 12 M materials (Lots 6–10); (c) Four lots of the 3 M materials (Lots 11–14); (d) Four lots of the 3 M materials (Lots 15–18).

demands of the market in situations in which plants require adaptations that allow them to occupy microclimates within different landscapes in addition to the aesthetic qualities required in landscape design. Lots 5, 10 and 17 harmonized in environments and gardens where the colours and showiness of the flowers need to be highlighted.

PP: the field trial survey

Plants are a highly visual form of merchandise and should attract more visual activity from individuals who are interested or involved at the time of purchase (Behe *et al.*, 2013). Plant height, number and diameter of flowers and

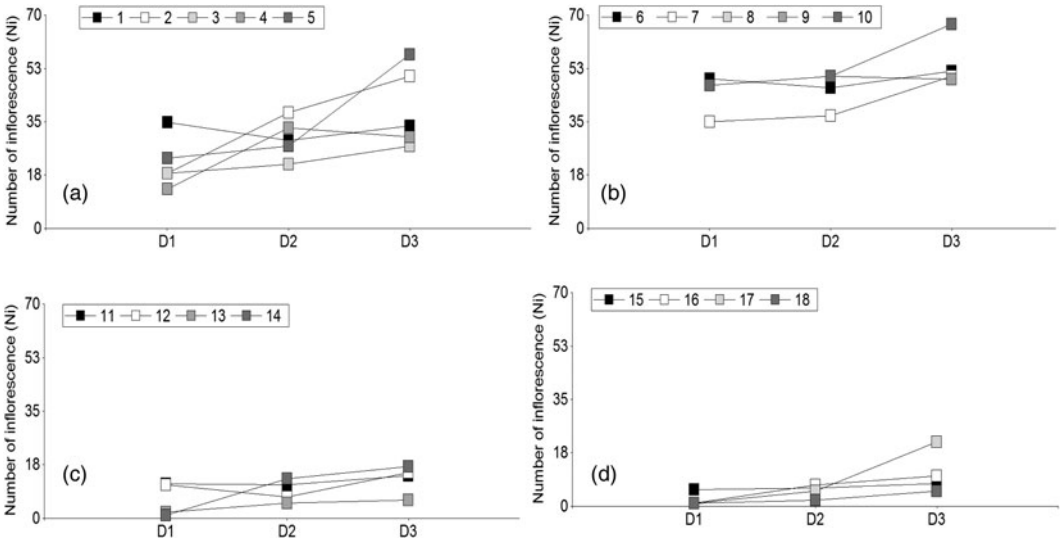

Fig. 2. Changes in number of inflorescences throughout the growing season for the different *Glandularia* hybrid materials in process of improvement tested in landscape conditions: Materials were divided into four figures to better visualize their differences: (a) Five lots of the 12 M materials (Lots 1–5); (b) Five lots of the 12 M materials (Lots 6–10); (c) Four lots of the 3 M materials (Lots 11–14); (d) Four lots of the 3 M materials (Lots 15–18).

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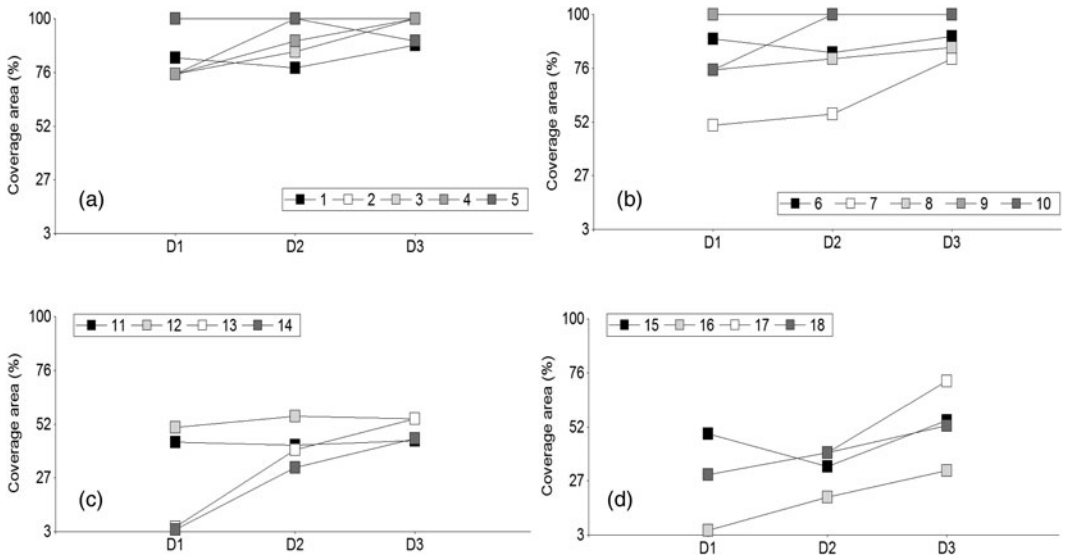

Fig. 3. Changes in coverage area (%) throughout the growing season for the different *Glandularia* hybrid materials in process of improvement tested in landscape conditions: Materials were divided into four figures to better visualize their differences: (a) Five lots of the 12 M materials (Lots 1 to 5); (b) Five lots of the 12 M materials (Lots 6–10); (c) Four lots of the 3 M materials (Lots 11–14); (d) Four lots of the 3 M materials (Lots 15–18).

thickness of a plant are also important properties to select bedding plants (Vabrit, 2002). In the composition of their garden, people prefer aesthetic traits such as flower size, leaf width and foliage colour (Kendal *et al.*, 2012). Different plant traits are related with people preferences and they constitute the primary factor to purchase, but the promotion of low water conserving landscape plants may also imply marketable benefits (Knuth *et al.*, 2018). In the surveys conducted during this project, preferences for some remarkable hybrid materials were related to

Table 2. Integrated ornamental bedding fitness index (IOBFI), public preference (PP) and ornamental bedding fitness index (OBFI) for three months (3 M) and twelve months (12 M) hybrids of *Glandularia*

Lots	Material	Hybrid	IOBFI	OBFI	PP	Order
17	3 M	UCC#6210032012	0.46	0.523	0.4	8
13	3 M	UCC#5701112011	0.39	0.392	0.4	9
12	3 M	UCC#2210012010	0.37	0.348	0.4	10
14	3 M	UCC#5922102011	0.17	0.348	0	12
18	3 M	UCC#6525032012	0.12	0.240	0	13
11	3 M	UCC#1120122009	0.11	0.207	0	14
15	3 M	UCC#6022102011	0.07	0.142	0	16
16	3 M	UCC#6122102011	0.07	0.142	0	16
6	12 M	UCC#2606102010	0.92	0.849	1	1
5	12 M	UCC#2105012010	0.90	0.806	1	2
8	12 M	UCC#3721122010	0.57	0.751	0.4	6
2	12 M	UCC#615122009	0.63	0.675	0.6	4
9	12 M	UCC#4029122010	0.79	0.98	0.6	3
3	12 M	UCC#815122009	0.625	0.849	0.4	5
7	12 M	UCC#2708122010	0.54	0.675	0.4	7
10	12 M	UCC#4605012010	0.63	0.86	0.4	4
4	12 M	UCC#1520122009	0.35	0.697	0	11
1	12 M	UCC#113122009	0.09	0.1905	0	15

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Table 3. Categorization of public votes by lots of all *Glandularia* materials (12 and 3 M)

Lot	Number of votes	Grade of categorization	Lot	Number of votes	Grade of categorization
1	No vote	None	11	No vote	None
2	7	Medium	12	2	Low
3	1	Low	13	1	Low
4	No vote	None	14	No vote	None
5	14	High	15	No vote	None
6	11	High	16	1	Low
7	1	Low	17	3	Low
8	1	Low	18	No vote	None
9	7	Medium			
10	3	Low			

these plant traits. This public scored some *Glandularia* hybrid according to some aesthetic traits (number of flowers, plant architecture and flower colour) that are usually present in different materials of the ornamental market (Vabrit, 2002; Kendal *et al.*, 2012).

IOBFI: breeder and public characterization together

On the other hand, the differences in the scoring for 12 M plants may be due because potential consumers generally base their decisions on a global perception of the product (i.e., it is not possible to distinguish individual 12 M plants), rather just one or few characteristics of the whole group of 12 M plants (Behe *et al.*, 1999). Asking potential consumers how much they like only one aspect of each material (e.g., flower colour), it may not be the best indicator of their overall preference for the product, or of the importance of a single trait in the purchase decision (Behe *et al.*, 1999). Thus, the results of this study could be an initial approximation to know people preferences of potential ornamental *Glandularia* hybrids. Moreover, preferences on some selected materials could be appreciated differentially according to their developmental stage.

Conclusions

Glandularia hybrids were characterized in the process of improving its bedding performance; they were evaluated by using some aesthetic traits as Ca, Nb, and Ni. Specialized PP combined with breeders analysis, allowed obtaining a ranking of selected materials. In particular, different aesthetic perceptions between the breeder and the public determining their preferences of ornamental plants were integrated through a combined index. *Glandularia* hybrids showed that certain traits selected by breeders, which are part of the ornamental bedding fitness index, seem to be good estimators of potential consumer preferences in the ornamental regional market, particularly at early developmental stages.

Supplementary material

The supplementary material for this article can be found at https://doi.org/10.1017/S1479262118000321.

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