Scientia Horticulturae 168 (2014) 17–26

Contents lists available at ScienceDirect

Scientia Horticulturae

journal homepage: www.elsevier.com/locate/scihorti

Assessment of the visual quality of ornamental plants: Comparison of three methodologies in the case of the rosebush

P. Santagostini[a], S. Demotes-Mainard[b], L. Huché-Thélier[b], N. Leduc[c], J. Bertheloot[b], V. Guérin[b], J. Bourbeillon[d], S. Sakr[d], R. Boumaza[d,*]

[a] Agrocampus Ouest, F-49045 Angers Cedex, France
[b] INRA, UMR1345 IRHS (Institut de Recherche en Horticulture et Semences), SFR 4207 QUASAV, F-49071 Beaucouzé, France
[c] Université d'Angers, UMR1345 IRHS, SFR 4207 QUASAV, PRES L'UNAM, F-49045 Angers, France
[d] Agrocampus Ouest, UMR1345 IRHS, SFR 4207 QUASAV, F-49045 Angers, France

ARTICLE INFO

Article history:
Received 16 July 2013
Received in revised form
28 November 2013
Accepted 7 January 2014

Keywords:
UPOV
Rose
Aesthetic quality
Sensory analysis
Floribundity

ABSTRACT

The quality of ornamental plants can be appraised with several types of criteria: tolerance to biotic and abiotic stresses, development potentialities and aesthetics. This last criterion, aesthetic quality, is specific to ornamental plants and objective measurements are required. Three methodologies for measuring aesthetic quality have been proposed. The first involves classical measurements of morphological features, such as flower number and diameter or leaf size. The second is based on sensory methods recently adapted to ornamental plants. The third, used by the International Union for the Protection of New Varieties of Plants (UPOV) for distinctness, uniformity and stability (DUS) tests, is based on morphological characteristics calibrated on specific reference varieties. The aim of this work was to compare these three methodologies for assessing some flowering and foliage characteristics of rosebushes. Six plants from 10 rose varieties identified by UPOV as reference varieties were cultivated for two years in a greenhouse and outdoors in Angers, France. They were measured and photographed weekly during flowering. Photographs of the plants in full bloom were submitted to a panel of judges for sensory assessment. The results of the three assessment methodologies were compared. Sensory and morphometric measurements were highly correlated and sensory measurements confirmed UPOV scales, whereas some morphometric measures diverged slightly from UPOV scales. We discuss the advantages, disadvantages and complementarity of these three methodologies.

1. Introduction

Quality is defined by the ISO 8402-1986 standard as "the totality of features and characteristics of a product or service that bears its ability to satisfy stated or implied needs". The quality of plants can be appraised with several types of criteria: tolerance to biotic and abiotic stresses, development potential and aesthetics, a criterion specific to ornamental plants (Habib et al., 1997; Dijkshoorn-Dekker, 2002; Heuvelink et al., 2004; Giorgioni, 2007). The measurement of aesthetic quality is necessary for objective studies, such as modelling or assessing the effects of various treatments. However, as pointed out by Boumaza et al. (2009), the multiple possibilities make it difficult to measure.

The characteristics of aesthetic quality to be taken into account depend on the type of ornamental plant considered: trees, shrubs, bushes or cut flowers. However, some of these characteristics may be common to several plant categories. We focus here on the rosebush, a model plant in ornamental horticulture, considering only visual aspects and ignoring all considerations relating to scent. Furthermore, we do not aim to characterise the visual quality of all the aerial parts of the plant. Indeed, this aspect has been dealt with in previous studies based on the use of tools and methods from the domain of sensory analysis (Boumaza et al., 2010; Huché-Thélier et al., 2011) or architecture analysis (Morel et al., 2009; Crespel et al., 2013). Instead, we focus on the partial evaluation of flowers and leaves, two of the principal determinants of the visual quality of the rosebush.

Floribundity is defined as "the capacity of a plant to produce abundant flowers at high density on each of its branches" (http://fr.wiktionary.org/, 10/11/2012). However, should we take into account the number of flowers at peak flowering or

Abbreviations: UPOV, International Union for the Protection of New Varieties of Plants.

* Corresponding author. Tel.: +33 241225481; fax: +33 241225599.
E-mail addresses: pierre.santagostini@agrocampus-ouest.fr (P. Santagostini), sabine.demotes@angers.inra.fr (S. Demotes-Mainard), lydie.thelier@angers.inra.fr (L. Huché-Thélier), nathalie.leduc@univ-angers.fr (N. Leduc), jessica.bertheloot@angers.inra.fr (J. Bertheloot), vincent.guerin@angers.inra.fr (V. Guérin), julie.bourbeillon@agrocampus-ouest.fr (J. Bourbeillon), soulaiman.sakr@agrocampus-ouest.fr (S. Sakr), rachid.boumaza@agrocampus-ouest.fr (R. Boumaza).

0304-4238/$ – see front matter © 2014 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.scienta.2014.01.011

throughout the year? In its guidelines, UPOV specifies that all observations should be made when the plant is in full flower (UPOV, 2010). Hereafter, we refer to this measurement as the peak floribundity index. The longitudinal floribundity index is the variation of the floribundity index during a season. Another related question concerns the stage at which flowers should be counted. Should we count all flowers, regardless of their stage of development (buds, opened, withered, rose hips) or only fully opened flowers? If we focus on the vitality of the plant, it would be tempting to consider all the flowers. However, if we are more concerned about visual quality, we may wish to restrict the flower count to opened flowers – that is, flowers with visible petals – and rosehips. Indeed, these two types of organ are brightly coloured and stand out from the foliage of the rosebush, which is usually green once the leaves have fully emerged. The peak floribundity index reported here takes into account all flowers but not the rosehips, whereas the longitudinal floribundity index takes only open flowers into account. We characterised floribundity by three types of methods or methodologies: the morphometric methodology, the sensory methodology and the UPOV methodology. The flower and leaf dimensions were characterised by the morphometric and UPOV methodologies.

The morphometric methodology is classically used in agronomy. It includes all methods based on counting, such as flower, leaf or axis counts, methods based on the measurement of dimensions, such as the diameters and heights of flowers, the lengths and widths of leaflets and stem length, and methods based on image analysis.

The sensory methodology involves the methods and tools initially used in sensory analysis. These methods were originally developed in the agro-food industry and have since been extended to other domains. They have recently been adapted for the objective characterisation of the visual quality of ornamental plants, as perceived by the human eye, which can be considered as a measurement instrument in this context (Boumaza et al., 2009). These methods require the choice of appropriate descriptors, the constitution of a jury of about 15 judges and the evaluation of each descriptor for each product. Two applications (Boumaza et al., 2010; Huché-Thélier et al., 2011) have demonstrated the relevance of such methods to ornamental horticulture, a sector in which visual quality is an important component of the commercial value of the products.

The UPOV methodology is based on the DUS (distinctness, uniformity and stability) requirements laid down by UPOV (1990) for the examination of cultivars or varieties for the acquisition of plant breeders' rights. This method is based on scoring rosebushes on a scale of 1 to 9 for characters identified as useful for distinguishing between varieties or for evaluating the uniformity and stability of a variety. Scores of 1, 3, 5, 7 and 9 correspond to examples of varieties that will be referred hereafter as reference varieties (Table 1). The most important feature of this method is that the relative behaviour of the reference varieties is identical in all environments. In some ways, this renders this approach almost international. In this study, we also considered the relevance of this approach, although this was not the principal objective.

The reference varieties studied here were those used between 1990 and 2010. The recommendations for the DUS examination were subsequently modified in 2010 (UPOV, 2010). This modification led to changes in the reference varieties for the two characters considered. However, this does not undermine the importance of this work, which was begun in 2008 and focuses on a key question: Is it possible to decrease the costs of rosebush evaluation when using a sensory method, and if so, how? Indeed, if the requirements for the reproducibility and repeatability of measurements are to be respected, the sensory method is more expensive than morphometric analyses. Furthermore, neither of these two methods has the almost international nature of the UPOV method.

The aim of this study was, therefore, to compare these three methodologies. We evaluated floribundity, and the flower and leaf dimensions of UPOV reference roses, and then compared the results obtained and considered the advantages and disadvantages of each methodology. For validation of some of the findings of these comparisons, we also considered the data obtained for rosebushes by Boumaza et al. (2010), referred to hereafter as supplementary data.

2. Materials and methods

2.1. Plant material and growing conditions

Ten rosebush varieties, listed in Table 1, were cultivated at Angers, France (latitude: 47°30′N; longitude: 0°35′W; altitude: 56 m). The rosebushes were grafted onto *Rosa corymbifera* 'Laxa', except for the 'Sweet Promise' variety, which was grafted onto *Rosa canina* 'Schmids Ideal'. Experiments were conducted in a greenhouse from November 2008 to April 2010 and outdoors from April 2010 to September 2011.

2.1.1. Growing conditions in the greenhouse

In November 2008, 60 rosebushes (6 per variety) were planted in 7-L pots, in a substrate composed of peat, coconut fibre and perlite (60/30/10, v/v/v). The pots were randomly placed on a shelf in six rows, 0.75 m apart and then pruned. The plants were drip fertiirrigated with a liquid fertiliser (Servital®, with a 3–2–6–0.6 balance of N–P_2O_5–K_2O–MgO, a pH of 5.8 and a mean electrical conductivity (EC) of 1.8 mS cm^{-1}, including the EC of water, which was 0.3 mS cm^{-1}). Each plant received between 330 mL of solution every two days in winter and 1330 mL per day in summer. Pests and diseases were controlled. Additional lighting (60 μmol m^{-2} s^{-1} of photosynthetically active radiation) was provided by sodium vapour lamps when total radiation levels outside the greenhouse fell below 200 W m^{-2}. Daylength was extended to 16 h. From March to September 2009, corresponding approximately to the measurement period, mean diurnal temperature was 25.6 °C (minimum: 18.4 °C and maximum: 45.0 °C) and mean humidity was 48% (minimum: 15% and maximum: 85%).

2.1.2. Outdoor growing conditions

In mid-April 2010, the 53 surviving rosebushes (7 had died) were transferred outside, together with new rosebushes to replace those that had died, to obtain six replicates per variety. They were planted randomly in six blocks, 2 m apart, on a silty clay soil covered by a porous plastic mulching film. They were drip irrigated with 500 mL of tap water, without further fertilisation, per plant every non-rainy day, from April to September. Pests and diseases were controlled. From mid-April to September 2010, corresponding approximately to the measurement period for 2010, mean diurnal temperature was 19.5 °C (minimum: 3.1 °C; maximum: 36.7 °C) and total rainfall was 156 mm. During the 2011 measurement period, corresponding approximately from April to September, mean diurnal temperature was 19.1 °C (minimum: 6.2 °C; maximum: 35.9 °C) and total rainfall was 230 mm.

2.2. Morphometric measurements

2.2.1. Leaves

Measurements were made on the UPOV reference varieties for leaf dimension: 'Tancary', 'Mullard Jubilee', 'Kolima', 'New Daily Mail', 'Starina' and 'Meiblam', from 12 April to 10 August 2009 in the greenhouse and from 3 May to 10 August 2010 outdoors. The length of the rachis, and the length and width of all leaflets of the leaves located in the central third of each flowering shoot were measured when the terminal flower carried by this shoot withered. As reported for the 'Radrazz' variety by Demotes-Mainard et al.