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Published Version:
Giorgioni, M., Minelli, A., Felice, E., Orsini, F. (2020). Device-supported spread of experimental results in a rose trial garden. ACTA HORTICULTURAE, 1298, 607-612 [10.17660/ActaHortic.2020.1298.84].

Availability:
This version is available at: https://hdl.handle.net/11585/784391 since: 2020-12-14

Published:
DOI: http://doi.org/10.17660/ActaHortic.2020.1298.84

Device-supported spread of experimental results in a rose trial garden

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Abstract

The Rose Garden of the University of Bologna, where more than 1000 old and new rose species and cultivars are collected, includes an experimental field for the evaluation of landscape roses under low maintenance conditions, i.e., without irrigation, fertilization, phytosanitary treatments and pruning for the first 5 years after planting, and a mechanical pruning in the 6th year, just before dormancy breaking. Since 2002, about 160 new cultivars have been tested and characterized. Data concerning morpho-phenological parameters and disease incidence, the flower-cover index (FCI), the ornamental index (OI) and the graphs of flowering trend from April to October were elaborated each year and on average over the first five years after planting for every cultivar. The availability of these data could be very useful for The Rose Garden visitors, hobbyists, breeders, landscapers and nurserymen interested in a deeper information on the cultivars in field. The use of RFID techniques can be an easy means of spreading the experimental results and a way to broadcast changes in the garden, communicating up to date information in the same way as a public museum. The creation of datasheets started with the selection of the most suitable information for two types of users, professional and amateur. Data, recorded in a RFID microchip/cv can be viewed by visitors on personal mobile devices after downloading the app; amateurs have a direct and open access to information concerning commercial names, breeder, horticultural company, genealogy, curiosities and awards for each cultivar. Professionals can access the processed experimental data, too, by using a password sent after the online registration. The label with the cultivar name, used as microchip support, is practical and compatible with the distance for reading the microchip.

Keywords: landscape roses, RFID (radiofrequency identification), microchip, communication technologies

INTRODUCTION

The rose is the most widely known ornamental plant in the world, grown especially outdoor as a garden plant and in greenhouses for the production of cut flowers and flowering pots. Moreover, it is cultivated for niche products of economic importance in specific areas of the world, as essential oils in Morocco and France, or for pharmaceutical and culinary uses in Bulgaria, Sweden and Chile. Its success, versatility and ubiquity are undoubtedly due to the high genetic variability, well used by breeders since ancient times. No other ornamental plant is available in such a variety of shapes, sizes and colours of flowers and canopy form and sizes. The wide range of cultivars, continuously evolving, is the first cause of the widespread use of roses in gardens. Those in use are sometimes monospecific, and the amateurs' interest in collecting in the past is well documented, for example by P.J. Redouté (1817-1824), H. Repton (1813), Rogger (2007) and Fearnley-Whittingstall (1989). Today there are countless online sites of private and public rose gardens. Among these, the 69 gardens award the status of Garden Excellence by The World Federation of Rose Societies are certainly the most important. They are located in 25 countries (Argentina, Australia, Austria, Belgium, Canada, China, Czech Republic, Denmark, France, Germany, Great Britain, India, Israel, Italy, Japan, Monaco, The Netherlands, New Zealand, Northern Ireland, Pakistan, Portugal, South Africa, Spain, Switzerland and USA) and each one consists of from 1000 to 2000 species/cultivars, except for The Flower Festival Commemorative Park (JP), The Rosarium Sangerhausen (DE) and Il Roseto botanico 'Carla Fineschi' (IT) with about 7000, 6800 and 6500 types, respectively. These gardens have saved and are preserving germplasm for use in research, education, studies on biological diversity and the evolution of the market in rose bud supply. Moreover, thanks to the meticulous labelling and the qualified botanical classification inside the *Rosa* genus, they can be totally compared to botanical gardens. It follows that, like botanical gardens, several rose gardens are suffering from economic problems and risk closure, as happened in 2017 to The Royal National Rose Society Gardens near St Albans, Hertfordshire, UK. They failed to attract enough visitors and attain an adequate profit to cover the high costs for the garden maintenance.

Trial gardens are another kind of public or private rose garden, often supported by breeding companies and aimed at the evaluation of new cultivars for the garden. Several hundreds of new hybrids, pre-selected among millions of seedlings, are grown in these test fields located all over the world. Each year the collections are screened for floriferousness, plant vigour and habit, drought tolerance, hardiness, disease resistance, attractiveness, novelty and scent, before their release to the market. The 11 Allgemeine Deutsche Rosenneuheitenprü fung (ADR) independent trial stations in Germany and The Earth-Kind® Field Trial Gardens spread over 27 USA States (up to 39 in Texas), Bermuda, Canada, India and New Zealand are the most significant examples. The cultivars marked "ADR" or "Earth-Kind" are guaranteed to be easy and cheap to care for and able to grow with agronomic sustainable practices, given the specific environmental conditions of the garden. Moreover, each breeding company has its own trial gardens to evaluate its hybrids before introduction to the market or submission to international trials.

The strong link between cultivar and environment implies the need to evaluate plants under several environments and maintenance levels and justifies the high number of test fields.

The Rose Garden of the University of Bologna is a collection of >1000 old and new cultivars and about 40 wild species/accessions. It includes an experimental field for the evaluation of modern landscaping roses, one of the most suitable type of roses for the today's widespread need of environmental-friendly and cheap public and private green areas. The garden, located in the northern Italy, is managed with a low maintenance scheme, i.e., without irrigation, fertilization, phytosanitary treatments and pruning for the first five years from planting, and a mechanical pruning in the 6th year, just before dormancy breaking. A lot of data about plant morpho-phenological parameters has been collected, processed and published in scientific journals but is not easily available to visitors to the Rose Garden, including amateurs and professionals walking around plants.

The use of RFID (radio frequency identification device) and hand-held device technology could be a durable (10 years or more; Bowman, 2005) and cheap solution for spreading of experimental data and the bibliographic information on varieties, enriching the experience for visitors, hobbyists and professionals (e.g., nurseryman, breeders, landscapers). It could be a way to make the garden more attractive and provide up to date information in the way that a museum does (Wang et al., 2007; Lin et al., 2009; Patil et al., 2014), thus enhancing the experience of visitors (Lin et al., 2009). The system consists of a reader (hand-held device) able to receive information wireless by a tag made up of a microchip with an antenna, using radio waves (Ngai et al., 2008).

The use of RFID to support agriculture sustainability and plant and food traceability is starting now and is less widespread and established than in industrial and logistics sectors (Weinstein, 2005; Luvisi, 2016) and veterinary field for animal identification (Sorenson et al., 1995). However, RFID systems were tested for monitoring fruit harvesting in orchard (Ampatzidis and Vougioukas, 2009), clonal selection in grapevine (Pagano et al., 2010), protection of wild flora (The Associated Press, 2008) and the health of certified plants at nursery level for grapevine (Panattoni et al., 2018) and *Actinidia* (Luvisi et al., 2012a).

Moreover, the damages to vascular tissues of plant by internal RFID microchip implants for supporting traceability and property rights were evaluated for several important species to the nursery industry, such as citrus (Bowman, 2005; Porto et al., 2011), rose (Luvisi et al., 2010), ornamental *Prunus* cultivars (Luvisi et al., 2011a) and olive trees (Luvisi et al., 2012b).

Meanwhile, the applications of mobile devices with multi-tags to automatically associate a field position to database tables and to access information and services were developed to support botanical garden visitors (Naismith et al., 2005), to manage vineyards (Cunha et al., 2010; Luvisi et al., 2011b) and in Brazil for the purposes of forestry and managing trees in urban green areas (Luvisi and Lorenzini, 2014).

Overall the usefulness of RFID technology for urban green management and its expected spread in the next years to establish a direct communication between urban trees and urban residents or urban green managers (Luvisi and Lorenzini, 2014) suggested the value of testing a microchip-based system in The Landscape Rose Trial Garden. In this way, we anticipated being able to explore how to provide a personalized learning experience to visitors, amateurs and professionals alike, and to spread the experimental results of cultivar evaluation. At the same time, personal mobile devices (e.g., smartphone) could assume the rule of an 'intelligent' guide, able to provide information according to the visitor's needs and interest and above all attract young people.

MATERIALS AND METHODS

With the objective of selecting the most suitable landscape rose cultivars for northern/central Italy, about 160 new cultivars have been tested in one of the experimental rose field of the University of Bologna since 2002. The experimental station is located in the Po Valley (Lat.: 44.286218; Long.: 11.883515), which is marked by a yearly rainfall around 550 mm and a 2.5-month xeric period, from June to the mid-August. No fertilizers or pesticides were applied and irrigation was provided only during the first summer after planting. Only one mechanic, non-selective winter pruning was planned at the beginning of the 6th growing year, before dormancy breaking, for halving the height and width of the canopy. Morpho-phenological parameters, such as flower diameter, colour and number plant^{-1}, canopy height and area, disease resistance and self-cleaning scores (1 to 5) were collected from April to October, from the 2nd to the 5th year after planting. The data were processed by cultivar and flower colour group (white, pink, fuchsia, yellow, orange/salmon and red). Two indices were calculated to quantify the chromatic impact of plants at the flowering peak: flower covering index; FCI = (Max flower N. × flower area)/plant area; and the plant ornamental flowering value over season: ornamental index; OI=(integrated area of flowering trend over time × flower area)/plant area (Giorgioni, 2007).

The vegetative plant growth, useful for setting the planting density, was analysed by involved area plant^{-1} (IA = canopy length × width) and coverage percentage (CP = plant area/involved area), and recorded yearly by photos.

The system for 'cultivar smart identification' includes the use of passive UHF RFID tags (Higgs-3 Alien Tech., CA-USA) which have the following features: 52×43 mm inexpensive microchips, 800-bit memory, readable within a 2 m range, protected from the elements, IP68 waterproof and with an operating temperature from -25 to 85°C. The label with the cultivar name is made of a plate (12×8 cm) on a 50 cm-long support stick that is stuck in the soil. This contains the tag, one per cultivar.

RESULTS AND DISCUSSION

The visitor's smartphone works as a 'RFID reader' thanks to an app developed by the students in Electronic Engineering of The UNIBO University, following the structure in Figure 1. The programmed mobile apps can work only inside The Rose Garden, near plants, because the increase of visitor number as much is possible is one of the most important purposes of the project. The system scheme expects two users: amateurs and professionals (e.g., landscapers, gardeners, breeders, public green administrators, researchers, nurserymen, plant traders). The creation of datasheets started with the selection of the most suitable information for the two types of users and therefore the definition of 'fields' and 'records'. The records, represented by rows, include all the data of a cultivar; the fields, are represented by columns, one for each provided information, starting from the exhibition name, photos of flowers, plant at the maximum of flowering and plant without flowers, to the position code in the field, the registration name, the plant synonyms, breeder, introducer (2 fields), parentage, polyploidy, awards (10 fields), colour of flower, flowering graphic, plant area, plant height, FCI, OI, disease resistance, flower self-cleaning, scores for flower colour fading, and plant adaptability to area.

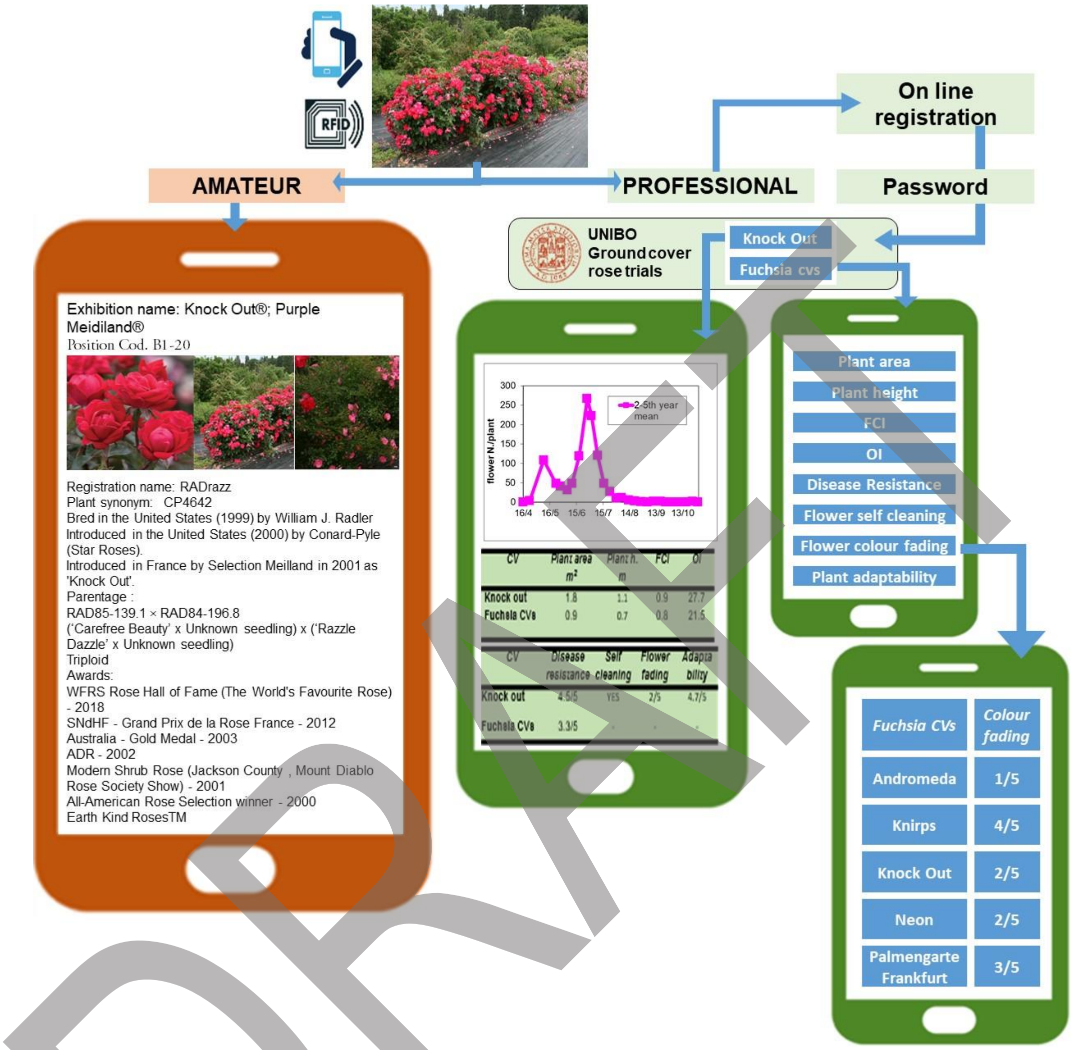

Figure 1. Scheme of the RFID tag application for hobbyists and professional visitors of the Landscape Rose Trial Garden of the University of Bologna.

The hobbyist has an open and direct access to photos of flowers and plants with and without flowers. Moreover, he/she can view data concerning commercial names, the breeder, the horticultural company that introduced the material to the trade, genealogy, curiosities and awards for each cultivar. On the other hand, professionals can access wider information, but only by using a password sent after online registration. They can choose to acquire the data by cultivar or flower colour group and select one of the eight available characteristics (i.e., 'fields'): plant area and height, FCI and OI, disease resistance, flower self-cleaning, colour fading and plant adaptability/hardiness. The last four fields are quantified by score from 1 to 5. The option 'cultivar' allows comparison between data of a specific cultivar and the means of its colour group and provides the flowering trend graph from April to October (flower number plant^{-1} as mean of three plants and five years; Figure 1).

At present, the project is still in progress, slowed down especially by the long process for data transfer to worksheets, graphs included, for the 140 cultivars actually grown in the field. The app is in the validation phase after combining microchip and plant for 'sample' cultivars.

The first experience of using the RFID microchip system on a few cultivars is promising and could be considered the starting point for the extension to all cultivars in the trial garden. However, several aspects have to be verified, such as the compatibility of the RFID tags and the different types of mobile devices, the disturbance action of water/humidity on RF signal transmission and the password administration. The use of labels as support for tags is a practical and economic solution, avoiding the tissue damages linked to the direct microchip implantation in the plant stem, as found in roses at nursery level (Luvisi et al., 2010). Moreover, the support allows the use of bigger passive tags, able to hold much more complete and complex information and to develop the system to an integrated, interactive and continuously improvable system. For example, visitors could directly input their cultivar evaluation (feedback) and the system be profitably used by the international judges on the International Trial Day for faster score processing. Furthermore, the system improvement by associating the electronic identification labels and sensors with the collection of environmental data could contribute to a more sustainable garden management, too. These opportunities confirm the RFID tag supremacy over bar codes and QR codes.

In conclusion, we can forecast today the diffusion soon of RFID systems into the management of germplasm collections, gardens, parks and experimental fields to ensure a friendlier and enriched experience to visitors and spread the results of research. In the near future, their use could contribute even more high-tech solutions.

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