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Radiofrequency applications in grapevine: from vineyard to web

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Abstract

An experimental trial was commenced in January 2007 of a traceability system for grapevine plants produced in a nursery and for electronic management of vineyards. The main objective was producing grafted cuttings using common nursery procedures, but in which were internally installed Radio Frequency Identification chips. The trial used five common Tuscan grapevine clones. The modified plants were indistinguishable from unmarked plants, and will maintain this electronic feature throughout their life. The marked plants can be easily monitored, and will be able to supply various information, including identity, growth parameters, susceptibility to biotic stress factors, and productivity. All information is available by a website accessing a database, guaranteeing that users (e.g. nursery workers, grapevine growers, and plant pathologists) can use online access to retrieve information on every marked plant.

Keywords: Traceability system**,** RFID chips, Grapevine marked plants.

1. Introduction

Radio Frequency Identification (RFID) technology is an interesting tool to satisfy traceability requests of the plant sector; however, there are few published trials on testing and evaluating plants integrated with electronic components**.** There is no information on production of grafted cuttings in which a microchip is installed, and no reported data regarding effects of microchip implementation on physiological properties. The RFID technology has been successfully used in various commercial sectors from many years, in particular for logistics and shop management, hospital patient identification and authentication, the transport sector, electronic tickets, tribunals, animal identification and environmental monitoring. Recent research (2006–2007) by RFID Observer of "Politecnico di Milano", showed > 830 applications of this technology in 600 companies in Europe, with an increase of 70% in the last year (http://www.osservatori.dig.polimi.it/). The predicted economic impact of these applications is about one trillion euros**,** a business of sufficient interest to the European Commission to lead in November 2006 to a specific law to harmonize radiofrequency apparatus operating in the UHF band (2006/804/CE).

In the agricultural sector, development of new systems for traceability have led to experiments with RFID technology in various conditions, mainly related to logistics. The use of micro-sensors incorporated into products or boxes permits continuous monitoring of items, and RFID systems are probably one of the best solutions for logistic and warehouse management in the horticultural sector (Purvis et al., 2006). Moreover, there are potential interesting applications of these methods in safety and traceability protocols in the food sector (Jones et al., 2005).

Marking organisms with microchips has been used for some years on pets and in animal breeding (Sorensen et al., 1995; Buguk et al., 1998; Caceci et al., 1999), but only in limited

trials on plant integration. The first experiments on electronic marking of plant samples for health and genetic evaluation were traditional plastic tags installed externally (Kumagai and Miller, 2006). Such systems have numerous advantages, as they are simple to use and do not damage plants; however, they can be removed, lost or damaged. Thus, they do not provide the most important traceability attribute, the assurance of permanent integration of tag with plant. Kumagai and Miller (2006) showed the potential of information technologies (RFID, GPS, images, and audio) for plants, managing data by an integrated system for reading (by Personal Digital Assistant, smart phone, etc.), which can remotely update a database. Systems for integrating microchips in plants are being developed (Bowman, 2005; Grieco et al., 2006) and do not seem to affect growth; so far there is preliminary evidence only, on plants that tolerate procedures similar to awl grafting.

In the grapevine sector, electronic marking by RFID technology was recently investigated to design a system for tracing plants produced in nurseries, and for electronic management of various types of vineyards by the Dipartimento di Ortoflorofrutticultura of University of Firenze and Dipartimento di Coltivazione e Difesa delle Specie Legnose “G. Scaramuzzi” of University of Pisa (Luvisi, 2007; Triolo et al., 2007). Trials were of grafted cuttings produced in nurseries, in which a RFID based microchip (TAG) was internally installed. The trial used five common Tuscan grapevine clones. The TAG was suitable for use in food or organisms. The modified plants of were indistinguishable from unmarked plants, and will maintain this electronic feature throughout their life. Thus, the plants can be easily monitored and are able to supply considerable information, including data about their origin, growth parameters, susceptibility to biotic or abiotic stress factors, and productivity. Some advantages connected with grapevine traceability with RFID systems are linked to recent legal documentation (2002/11/CE, 2005/43/CE) concerning "certificate" grapevine production. This assures higher genetic and plant health qualities are available in the marketable products**.** The identification

of every single plant makes substitution errors impossible, and is a useful tool for those controlling the materials.

2. Materials and methods

Transponder glass TAG RFID were used, 2.11 mm diameter and 12 mm length, working at the frequency of 125 KHz (Intermedia Sas, Forlì, Italy; www.rfid360.net). TAGs where read electronically 14-length identification number, and the reading was performed by a Card Flash reader able to identify the microchip from a distance of 20 cm. Data recovery was performed by a palm-PC (Dell Axim X51).

An online database was specially developed for matching TAGs to information datasheets for users to manage the marked plants. The aim of system was to permit online access to datasheets by users involved in the grapevine production line – from grapevine producer to farmer – using the identification codes linked to TAGs. Datasheets and their access were designed considering privacy policy, with regard to each type of user: considering that the final user – the grapevine grower – could access all information regarding each single purchased plant, while the pre-multiplication center or nursery could access only production information. Thus, the editable fields of datasheets follow similar rules.

The online database for managing marked plants was developed by InterMedia Sas, and can be found at the website (http://www.toscovit.it/) of Associazione Toscana Costitutori Viticoli (Association of Tuscan Grapevine Constitutors, TOS.CO.VIT.), which owns the database. The database is classified as a distributed Rich Internet Application (RIA system) and is installed on a remote server, while Flash technology is used for clients. The main software used is Java™ and Adobe® Flex®.

The database was designed considering the relationship between users and products. To enter inside the traceability of a line**,** a registered account is required for user identification. The types of users are the pre-multiplication center, constitutor, nursery and farmer; and account validation (by letter) is performed by TOS.CO.VIT.

The system was tested evaluating TAGs reliability after two years inside plants. Alpha testing and Beta testing of database were performed. Alpha version was tested by developer and Authors, while Beta version was distributed to panel of Tuscan grapevine constitutors, nurseries and farmers, to test usability of database. Each version was tested using Microsoft® Internet Explorer® 6.0-8.0, Mozilla© Firefox© 2.0-3.5.

3. Results

3.1. Editing and access to database

After login, the reference code or TAG code of a marked plant is required to access datasheets. The reference code is a comprehensive code regarding a stock of similar marked plants, while the TAG code refers to a single microchip: the former is reported in documentation attached to the purchased plants, and the latter is readable by a RFID reader. This difference in codes is to guarantee access to information even for those who do not have a RFID reader or do not want use it. Moreover, reference codes that do not directly refer to each plant are more easily managed, leaving the single-plant access until inside the database, where complete codes are reported. Codes can be digitally entered into the search field of the database, and the datasheet is then shown, with all protagonists of the production line registered. The code can be considered as an electronic identity card (eID) for each plant (not

only mother plants, i.e. www.certabasilicata.it), differently from traditional label that are not placed on every single plant, but on groups of grapevines joined by laces.

There are different duties and privileges according to the kind of users. The pre-multiplication center (Fig. 1) is the administrator of the database and can edit clone and rootstock files, and match them using the TAG code**.** Thus, the code – linked to one microchip – is used to edit the eID of each plant subsequently produced by the nursery.

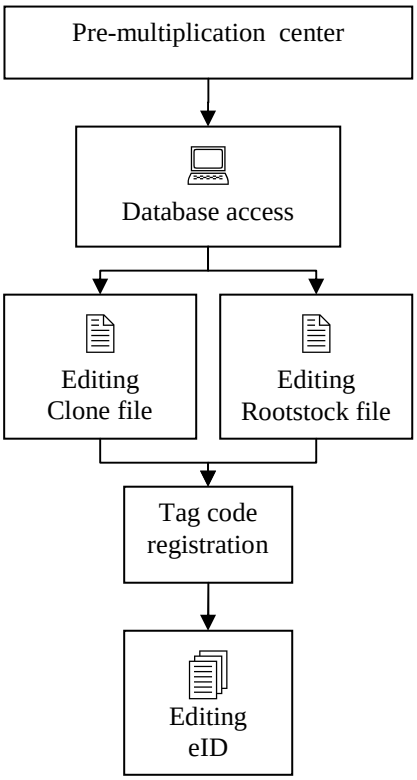

Fig. 1. Pre-multiplication center involvement in RFId grapevine traceability

Grapevine nurseries (Fig. 2) that access the database can view all data regarding clones and rootstock, and can complete the eID with commercial notes relevant to the grafted cuttings**.**

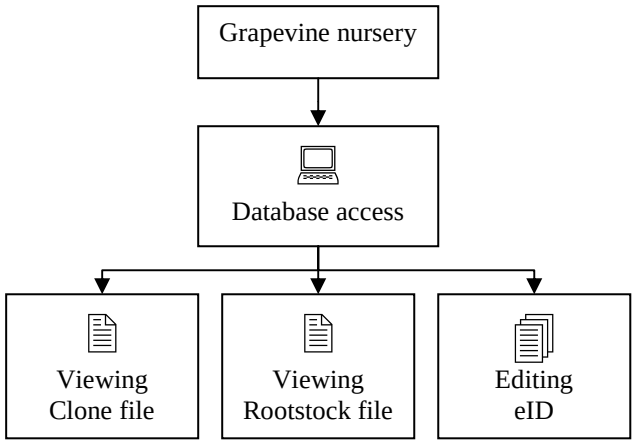

Fig. 2. Grapevine nursery involvement in RFId grapevine traceability

The grapevine grower (Fig. 3), besides consulting cutting files, can use the TAG code to access eID of plants bought, edit personal data fields, and manage whole marked plants (the "virtual vineyards").

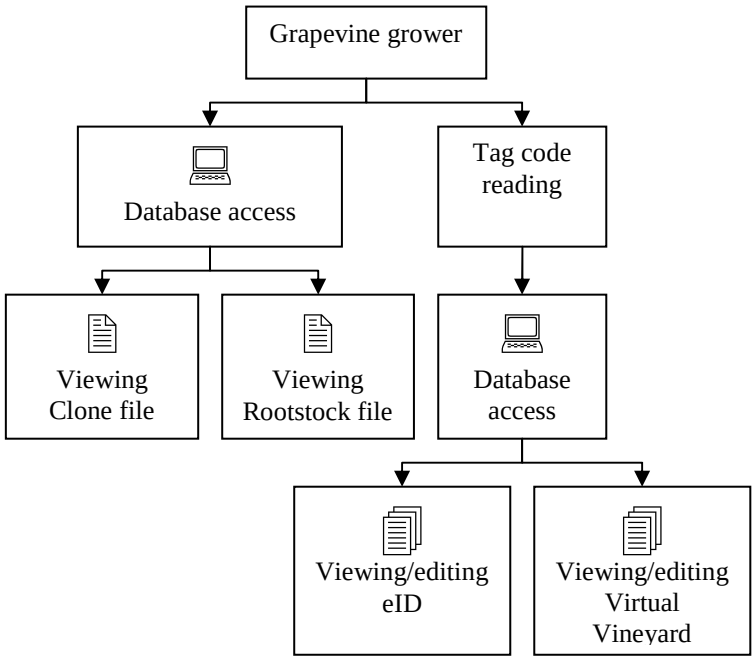

Fig. 3. Grapevine grower involvement in RFId grapevine traceability

3.2. The electronic identity card

The eID is generated by files edited by the pre-multiplication center and the nursery that refer to products – clones and rootstocks – and manufacturers, and eID provide genetic and certification data**.** (Fig. 4). This feature is an additional resource to conventional catalogues provided by pre-multiplication centers and nurseries, or can even substitute for them. The online access guaranteed by purchasing marked plants, allows digital delivery of documents regarding clones or rootstock. This digital link between manufacturers and farmers is an opportunity to establish a feedback relation to improve the eID considering different experiences of farmers with the product**.**

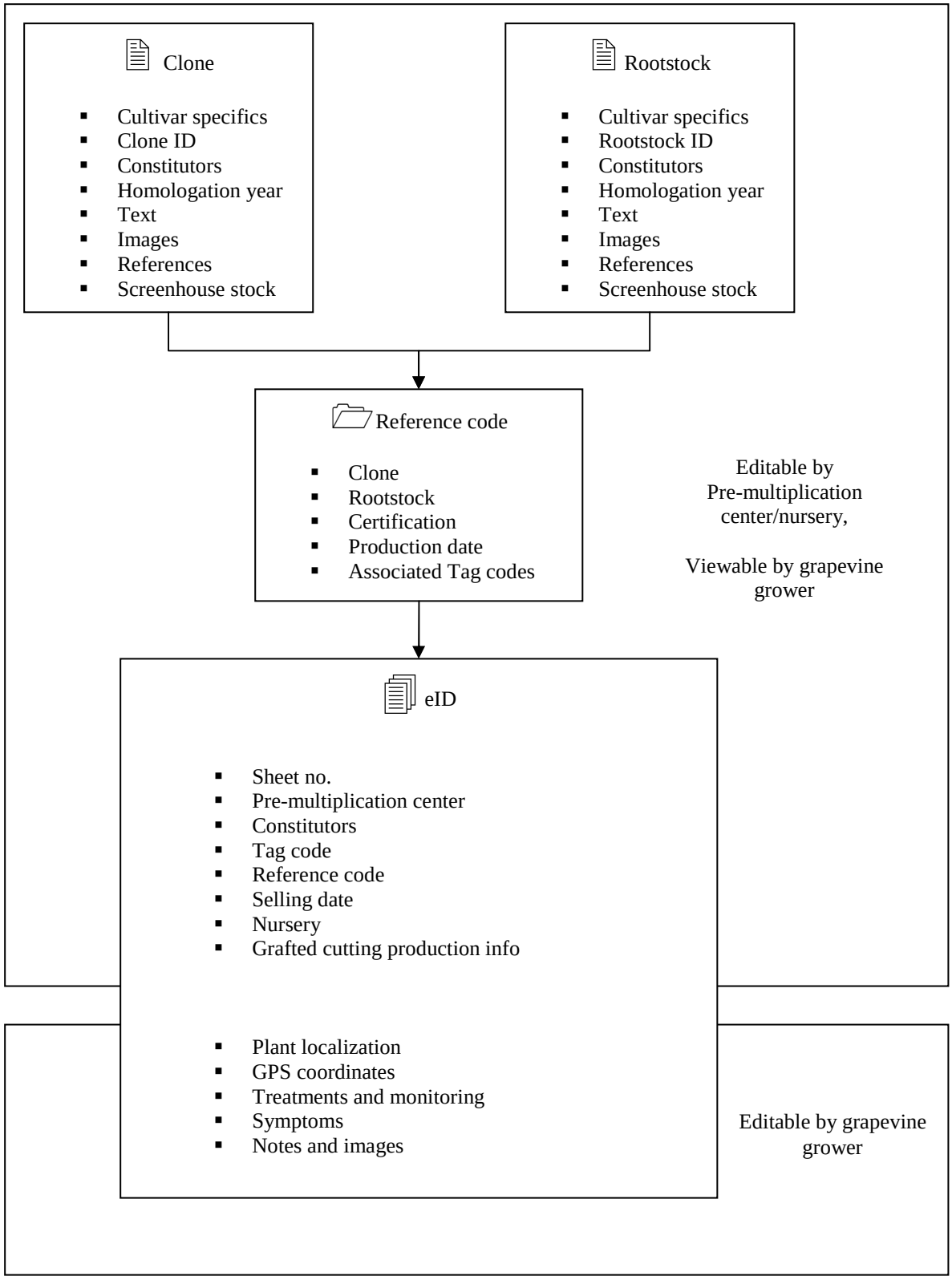

Fig. 4. Relations and information archived into database

3.3. Personal database

The specific eID for each plant can be updated by the grapevine grower with farming data to create a private “virtual vineyard” in which treatments performed, production, monitoring programs, GPS coordinates and other data are archived (Fig. 4). This function can help farmers in vineyard history registering, formerly done by handwriting or simply “kept in mind”. To enhance this feature and make it user-friendly, considering the large number of plants commonly grown in a vineyard, nursery workers and grapevine growers can access a personal database – automatically created by the main database – in which all sold/purchased plants are archived, for fast information recovery. This tool is essential for digital nursery/vineyard management, because sensible data regarding marked plants can be added easily to each eID, to constantly maintain up-to-date information about the user’s vineyard.

3.4. Tests

Only 0.2 % of TAGs were unreadable immediately after insertion inside grapevine, due to damage caused by implantation procedure. Two years of farming do not compromise TAGs reliability, with 100 % of readable microchips.

Alpha and Beta version feedbacks were adopted to edit final version of database, any difference in browser using was reported. Stakeholder panel judge the database user-friendly.

4. Final consideration and conclusions

Subjects in which a microchip is installed will be identified by a code, associated with the microchip itself, and they can be located (with Geographical Information System) on a three-dimensional electronic map, recreating a "virtual vineyard". This system will be evaluated

experimentally, with the aim to achieve and optimize electronic mapping techniques in indoor areas (i.e. screenhouses for grapevine collections, as reported in clonal selections procedures for selecting clones of grapevine), and outdoor areas, such as nurseries and vineyards, considering distinctive and unique properties of these different environments. This system is being developed by the authors and will be able to remotely monitor vineyards, archive and manage useful data associated with plants (i.e. identity, sanitary status, certification, and cultural practices) particularly using technical and plant health files**,** and supply a durable, safe and detailed vineyard information map. Another positive feature, useful mainly for vineyard management, is the possibility of modifying the data files from the field, thus upgrading and changing associated information of marked plants.

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