

# Polianthes Tuberosa as Edible Flower: In Vitro Propagation and Nutritional Properties

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**Abstract**—Tuberose (*Polianthes tuberosa*) is a bulbous species belonging to Asparagaceae family, characterized by a very high ornamental value, pleasant flower scent and taste. For all these reasons, flowers are currently used to produce perfumes or valorized as actual ingredient of different recipes, since they are completely edible. *P. tuberosa* is one out of 40 species studied in INTERREG ALCOTRA “ANTEA” project, which aim is to extend the use of edible flowers as functional food and enlarge the number of the species used for the supply chain of the edible flowers. Fresh flowers were analyzed in order to characterize them from the nutrition point of view. They show good polyphenols content and antioxidant activity (DPPH assay), while flavonoids, anthocyanins and carotenoids amounts are low. On the other hand, *P. tuberosa* flowers can be a real source of vitamin C, because of the high quantities of this molecule in the petals. Soluble sugars are present in small amount. High quantities of *P. tuberosa* flowers are difficult to obtain due to low bulb multiplication rate and poor seed germination. For these reasons, in vitro culture was performed to facilitate plant propagation. Bulbs were surface-sterilized for 30’ in ethanol 70 % and then for 20’ in NaClO 2.5 % solution, while seeds were surface-sterilized for 20’in NaClO 1 % solution. Both were rinsed twice with autoclaved distilled water for 10 minutes after sterilization. The bulbs were cultured in jars containing MS agarized substrate enriched with 3% sucrose, 1.5 mg/L BA, 0.5 mg/L IAA and 0.7% agar (pH 5.8). Seeds were germinated in Petri dishes with agar-water substrate and then 14 different clones were selected and cultured in jars. The multiplication rate of the clones was very variable but some of them reached a good multiplication rate.

**Index Terms**—Edible flowers, micropropagation, antioxidant, bioactive compounds, DPPH assay, vitamin C

## I. INTRODUCTION

*Polianthes tuberosa* L. is an ornamental bulbous plant belonging to Asparagaceae family and native to Mexico [1]. The bulbs produce flowers only once in their life, and each bulb grow an average of four years before producing

flowers. The leaves are elongated, arched and ribbon-shaped. At late summer, the plants produce spikes, where the flowers develop starting from the bottom to the top. The white pleasant flowers are characterized by a long vase-life (around 10 days) [2], with very high ornamental value, an intense and sweet fragrance, floral taste and crunchy texture. Floral aroma scent volatile changes during flowers lifespan, showing a nocturnal rhythm [3]-[5]. For all these reasons, flowers are currently used for producing perfumes [6] or valorized as actual ingredient in different recipes, since they are completely edible [7]. In Asia, bulbs and flowers are used to extract compounds with anti-inflammatory and antispasmodic, diuretic and emetic properties [8].

*P. tuberosa* is one out of 40 species studied in INTERREG ALCOTRA “ANTEA” project, which aim is to extend the use of edible flowers as functional food and enlarge the number of the species used for the supply chain of the edible flowers. Organically grown edible flowers are currently sold in rigid plastic containers, that can be purchased directly from the producers, both locally and through dedicated websites. In both cases, significant quantities of flowers are required to cover the consumers’ demand. In fact, edible flowers are gaining more and more popularity thanks to many scientific reports, that highlight their nutritive and healthy properties [9], [10]. Since few information are available about primary and secondary metabolites present in *P. tuberosa* flowers and [11], the main objective of this work was to analyze their total polyphenols, carotenoid, and ascorbic acid content, along with the quantification of their radical scavenging activity (DPPH assay) and soluble sugars (D-glucose, D-fructose and sucrose) concentration, in order to better characterize these flowers from the nutritional point of view.

On the other hand, high quantities of tuberose flowers are difficult to obtain due to low bulb multiplication rate and poor seed germination. For these reasons, *in vitro* cultivation techniques are performed in this work, in order to facilitate bulb propagation, in support of flowers’ commercialization.

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## II. MATERIALS AND METHODS

### A. Plant Material

Seeds and bulbs of *P. tuberosa* were provided by two growers of perfume plants: Sébastien Rodriguez (bulbs in pot and seeds) and Armelle Janody (only seeds). The bulbs, deriving from a single clone, were cultured in 9-liter pots (30 cm of diameter) containing substrate (Hochmoor – Terflor, Capriolo, BS, Italy) with slow release fertilizer (Nitrophoska, Eurochem Agro, Cesano Maderno, MB, Italy), were grown organically without the use of pesticides, and irrigated with nutrient solution (Ferti 3, Planta-Düngemittel, Regenstauf, Germany) every week. The pots were kept in a greenhouse with anti-insect net and located at CREA– Research Centre for Vegetable and Ornamental Crops (CREA, Sanremo, IM, Italy, GPS: 43.816887, 7.758900).

Forty bulbs of this clone were used to establish the *in vitro* culture, the remaining bulbs were used to produce edible flowers. Thirty seeds were stored at room temperature until *in vitro* seeding.

### B. Flower Analysis

Full-bloomed flowers were harvested in summer 2018 and immediately stored at  $-80^{\circ}\text{C}$  until analyses.

Flower colour was evaluated with a spectrophotometer SP60 series (X-Rite Incorporated, Michigan, USA), measuring  $L^*$  (lightness),  $a^*$  (redness) and  $b^*$  (yellowness) colour coordinates (CIELAB scale, CIE 1976). Twelve different and well representative measures were recorded in order to determine the flowers colour.

Frozen flowers (200 mg) were used to quantify total carotenoid content, total polyphenolic content, Total Flavonoid (TF) and anthocyanin content, as previous described [12]. Radical scavenging activity was determined by the DPPH assay [13], reporting the results as  $\text{IC}_{50}$  (mg/mL). Total and the reduced form of ascorbic acid were quantified according to the method of Reference [14]; sample extraction was performed following the protocol already described in literature [15]. Sucrose, D-fructose and D-glucose determination was performed using a Sucrose/D-Fructose/D-Glucose Assay Kit (Megazyme International Ireland, Co. Wicklow, Ireland) following the manufacturer's instructions and prior to the extraction described in [16]. (Fig. 1).

For each analysis, three biological replica were used. The absorbance was read in a UV-1800 spectrophotometer (Shimadzu Corp., Kyoto, Japan).



Figure 1. Inflorescence of a *P. tuberosa* clone grown in pot.

### C. Bulbs and Seeds Surface Sterilization

Forty bulbs were extracted from the pot, washed under running tap water to remove soil residues, surface-sterilized in a 70 % (v/v) ethanol solution for 30'' and then transferred in a 2.5 % (v/v) sodium hypochlorite ( $\text{NaClO}$ ) solution for 20' (clone B). In parallel, thirty seeds were surface-sterilized 1 % (v/v)  $\text{NaClO}$  solution for 20'. Bulbs and seeds were rinsed twice with autoclaved distilled water for 10 minutes after sterilization.

### D. In Vitro Culture of Bulbs and Seeds

The bulbs were cultured in tube containing 12 ml of MS propagation medium [17] agarized substrate enriched with 3% sucrose, 1.5 mg/L BA, 0.5 mg/L IAA and 0.7% agar (pH 5.8) [18] and kept at  $23 \pm 1^{\circ}\text{C}$  with a 16/8 h light/dark cycle and  $209 \pm 5 \mu\text{mol m}^{-2} \text{s}^{-1}$  light irradiances at tube level (white fluorescent Philips Master TL-D 36W/840 lamp). Only one bulb (B clone) was selected for subsequent propagation subculture in jars (Fig. 2).



Figure 2. In vitro culture of B clone in jar (bar = 1 cm).

The seeds were kept in Petri dishes containing agar-water substrate (pH 5.8) and placed to germinate in the dark at  $23 \pm 1^{\circ}\text{C}$ . Seed germination was checked weekly. After three months, the plants originated from seeds (S clones) were transplanted in jars containing propagation medium [18], already used during B clone multiplication phase.

After one year of subculture, the multiplication rate was recorded, namely the number of propagules deriving from a single plant of a clone (Fig. 3).

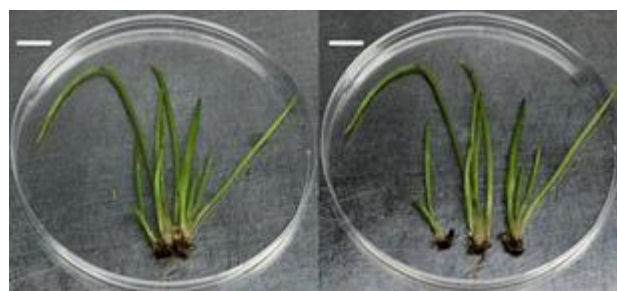


Figure 3. Evaluation of multiplication rate for S4 clone (bar = 1 cm).

### E. Acclimatization in Greenhouse

In spring, a total of 500 bulbs, obtained from four different *in vitro* clones with the highest multiplication rate, were acclimatized in cellular containers containing peat: perlite 1:1. The plants were watered if necessary and cultured in greenhouses at CREA of Sanremo and CREAM of Nice Cedex.

After three months, plant survival was recorded.

### F. Statistical Analysis

Data were statistically analyzed by one-way ANOVA. The significance of the comparisons was estimated by a Fisher's probable least-squares difference test with cutoff significance at  $p < 0.05$ .

## III. RESULTS

### A. Flower Analysis

*P. tuberosa* flowers analysed in this work were very closed to white ( $a^*$  e  $b^*$  coordinates not far from 0), with a high brightness value (Table I).

TABLE I. CIE  $L^*a^*b^*$  COLOUR PARAMETERS. DATA ARE REPORTED AS MEANS  $\pm$  STANDARD ERROR (SE) (N = 12).

Color specification	Means $\pm$ SE
$L^*$	$91.88 \pm 0.19$
$a^*$	$-2.10 \pm 0.03$
$b^*$	$8.27 \pm 0.18$

Secondary metabolites are differently represented depending on the class of compounds (Table I). Good amount of total polyphenols was quantified in *P. tuberosa* flowers, while the total flavonoid content was 5.3-fold lower. Anthocyanins were very limited (0.02 mg/g FW), as well as total chlorophylls and carotenoids (Table I).

On the other hand, flowers antioxidant activity was relevant. Significant concentration of ascorbic acid (vitamin C) was determined, and the reduced form of this molecules was very high (94.5%) compared to the oxidized one (5.5%, calculated by subtracting the percentage of the reduced ascorbic acid from the percentage of the total ascorbic acid content, set at 100%).

As regards primary metabolites, low amounts of soluble sugars were quantified, and the two monosaccharides measured in this work were around 1.6-fold higher than sucrose (Table II).

TABLE II. DETERMINATION OF SECONDARY METABOLITES, ASCORBIC ACID, RADICAL SCAVENGER ACTIVITY AND SOLUBLE SUGARS. DATA ARE REPORTED AS MEANS  $\pm$  STANDARD ERROR (SE) (N = 3). ABBREVIATION: FW – FRESH WEIGHT; GAE-GALLIC ACID EQUIVALENTS; CE – CATECHIN EQUIVALENTS; ME- MALVIN EQUIVALENTS

Parameters	Means $\pm$ SE
Total chlorophylls ( $\mu\text{g/g FW}$ )	$3.97 \pm 0.86$
Carotenoids ( $\mu\text{g/g FW}$ )	$2.33 \pm 0.39$
Polyphenols (mg GAE/g FW)	$3.53 \pm 0.10$
Flavonoids (mg CE/ g FW)	$0.66 \pm 0.03$
Anthocyanins (mg ME/g FW)	$0.02 \pm 0.00$
DPPH ( $\text{IC}_{50}$ mg FW/ml)	$1.61 \pm 0.05$
Reduced ascorbic acid (mg/100g FW)	$73.91 \pm 0.91$
Total ascorbic acid (mg/100g FW)	$78.23 \pm 0.95$
Glucose (mg/g FW)	$4.74 \pm 0.48$
Fructose (mg/g FW)	$4.47 \pm 0.46$
Sucrose (mg/g FW)	$2.80 \pm 0.29$

### B. Multiplication in in Vitro Culture

The multiplication rate of the clones was very variable. The average multiplication rate of each clone is shown in Fig.4. S4 and S13 clones showed the statistically significant highest average multiplication rate compared to other S and the B clone. The S7 clone had the lowest multiplication rate.

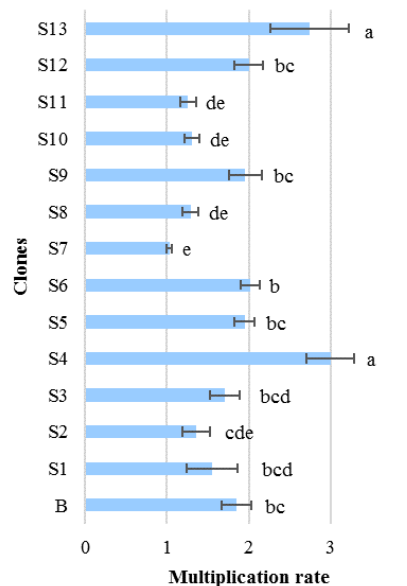


Figure 4. Average multiplication rate of *P. tuberosa* clones. B, clone from bulb; S, clones from seeds. Different letters indicates statistically significant differences at  $p < 0.05$  (Fisher's probable least-squares difference test).

### C. Acclimatization in Greenhouse

No difference in acclimatization rates was highlighted between the two greenhouse sites (CREA and CREAM) (data not shown). The acclimatization of the *P. tuberosa* bulbs from the *in vitro* culture has not been difficult. Indeed, almost all bulbs of the four clones (B, S4, S6 and S13) survived the acclimatization phase. Percentages were 99.3 %, 99.4 %, 100.0 % and 98.9 % for B, S4, S6 and S13, respectively.

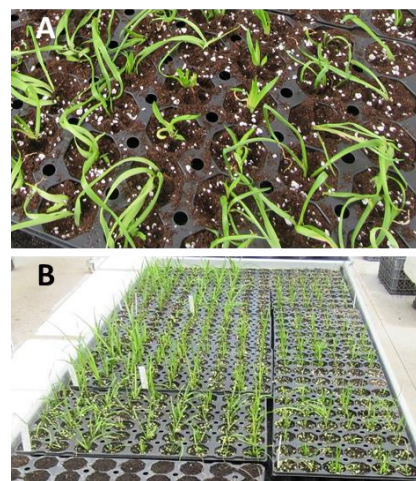


Figure 5. Acclimatization of the *P. tuberosa*. A. Bulbs from the *in vitro* culture just transplanted in greenhouse at CREAM of Nice Cedex; B. Bulbs in cellular containers after three months of *in vivo* culture.

#### IV. DISCUSSION

Even though *P. tuberosa* flowers are edible and traditionally consumed in different culinary preparations [7], poor information about their nutritive and antioxidant properties are reported in literature. When flowers of *P. tuberosa* L. (ecotype India) were extracted in methanol, reference [11] measured 180 mg of total polyphenols per gram of fresh weight (FW), along with a very high antioxidant activity (DPPH IC<sub>50</sub> value = 0.006 mg FW/ml). This value is quite far from the ones obtained in this work: 3.53 mg GAE/g FW and 1.61 mg FW/ml (DPPH IC<sub>50</sub>), respectively. This discrepancy could be due to differences in: 1) extraction methods; 2) plant material genotypes; 3) plant growth condition. In fact, reference [11] performed flower extraction in a ultrasonic bath of 45' with pure methanol as solvent. In this work, no sonication were carried out and the extraction solvent was a 70% (v/v) methanol solution. Moreover, reference [11] grown their plant in a experimental garden, instead of a greenhouse as in our work. This means that environmental conditions could be different, even if the season in which the experiment was performed and the age of the plant were comparable in the two works.

Carotenoids and anthocyanins are the major pigments of petals. Hybrids of tuberose with yellow flowers owe their colour to carotenoids, while anthocyanins confer pink, reddish-purple and purple flowers colorations [19]. The coexistence of anthocyanins and carotenoids allows to obtain orange flowers [19]. On the other hand, neither carotenoids nor anthocyanins are present in *P. tuberosa* varieties with white flowers [19]. Despite this previous work, little quantities of both pigments are measured in our study (Tab.1), that involved white flowers. Based on flowers observation to the naked eyes, yellow anthers and filaments could contain carotenoids, while anthocyanins could be responsible for the slight pink shades sometimes present on the petals.

Ascorbic acid is an important nutrient for the human diet, and some edible flowers contains relevant quantities of this vitamin, such as *Tagetes tenuifolia* (241.20 mg/100 g FW) [20]. Even if *P. tuberosa* flowers contain around 3-fold lower amount of ascorbic acid than the abovementioned species, its flowers can be a real source of this molecule since 25 g of petals (around 30 flowers) are enough to reach a quarter of the recommended daily intake for vitamin C [21].

Moreover, *P. tuberosa* flowers contain more ascorbic acid than other well-known edible species, such as *Borago officinalis*, *Bellis perennis* and *Begonia semperflorens* [20].

Regarding to soluble sugars, tuberose flowers are characterized by low amount of D-glucose, D-fructose and sucrose, compared to 4 different edible flowers belonging to *Agastache* family [22]. Nevertheless, *P. tuberosa* contain a higher sucrose percentage than 3 out of the 6 species analysed by reference [20].

As regards *in vitro* propagation techniques, the multiplication rates were different among clones. Obviously, genetic variability is a fundamental aspect, since some genes present in a clone could change the

response to the hormones present in the culture medium. This trend is observed in other species. A study carried out on *Nerine*, another bulbous ornamental plant, shows that different clones placed on the same *in vitro* medium have very different multiplication rates [23]. Also in tree species, like oak and myrtle, the researchers noted large variations of shoot productivity among clones and varieties, although under the same multiplication conditions [24], [25]. The selection of plants that display a good *in vitro* multiplication aptitude improves the commercial potentiality.

Epigenetic factors inherited from parents can affect the rate of *in vitro* multiplication. Some authors [26] state that, in plant tissue culture, DNA methylation and histone modifications can affect shoot proliferation and quality of propagules.

Acclimatization is in two steps: bulbs transplant and then bulb sprouting. With this system acclimatization percentages are excellent.

#### CONFLICT OF INTEREST

The authors declare no conflict of interest.

#### AUTHOR CONTRIBUTIONS

Conceptualization, Data curation, Formal analysis, Funding acquisition: B.R., L.P.; Investigation, Methodology, Project administration: B.R.; Supervision: B.R., L.P.; Writing—original draft: A.C., I.M.; all authors had approved the final version.

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#### REFERENCES

- [1] E. W. E. Trueblood, “Omixochtl - The tuberose (*Polianthes tuberosa*),” *Economic Botany*, vol 27 pp. 157-173, Apr. – Jun. 1973.
- [2] A. Kumar, S. Kumar, and S. Chandra, “Vase life studies in tuberose (*Polianthes tuberosa*) cv. SHRINGAR as affected by post harvest handling treatments”, *The Asian Journal of Horticulture*, vol. 5 pp. 7- 10, Jan. 2010.
- [3] M. Benschop, “*Polianthes*,” in *Physiology of Flower Bulbs*, A. D. Hertog and M. L. Nard, Eds., Elsevier, Amsterdam, The Netherlands. 1993, pp. 589-601.
- [4] S. Maiti and A. Mitra, “Morphological, physiological and ultrastructural changes in flowers explain the spatio-temporal emission of scent volatiles in *Polianthes tuberosa* L.”, *Plant Cell Physiology*, vol. 58, pp. 2095–2111, Dec. 2017
- [5] N. N. Kutty and A. Mitra, “Profiling of volatile and non-volatile metabolites in *Polianthes tuberosa* L. flowers reveals intraspecific variation among cultivars,” *Phytochemistry*, vol 162 pp. 10-20, Jun. 2019.



- [6] N. Dudareva and F. Negre, "Practical applications of research into the regulation of plant volatile mission," *Current Opinion in Plant Biology*, vol. 8, pp. 113-118, Feb. 2005.
- [7] T. K. Lim, "Polianthes tuberosa," in *Edible Medicinal and Non-medicinal Plants*, Springer, Dordrecht, The Netherlands. 2014, pp. 126-133
- [8] R. N. Chopra, S. L. Nayar, and J. C. Chopra, "Glossary of Indian medicinal plants," *National Institute of Science Communication, Council of Scientific and Industrial Research*, New Delhi, India p. 199, 1999.
- [9] L. Fernandes, S. Casal, J. A. Pereira, J. A. Saraiva, and E. Ramalhosa "Edible flowers: A review of the nutritional, antioxidant, antimicrobial properties and effects on human health," *Journal of Food Composition and Analysis*, vol. 60, pp. 38-50, Jul. 2017.
- [10] T. C. Pires, L. Barros, C. Santos-Buelga, and I. C. Ferreira, "Edible flowers: Emerging components in the diet," *Trends in Food Science & Technology*, vol. 93, pp. 244-258, Nov. 2019.
- [11] S. Maiti, U. R. Moon, P. Bera, T. Samanta, and A. Mitra, "The in vitro antioxidant capacities of Polianthes tuberosa L. flower extracts," *Acta Physiologiae Plantarum*, vol. 36 pp. 2597-2605, Jul. 2014.
- [12] I. Marchioni, L. Pistelli, B. Ferri, P. L. Cioni, A. Copetta, L. Pistelli, and B. Ruffoni, "Preliminary studies on edible saffron bio-residues during different post-harvest storages," *Bulgarian Chemical Communication*, vol. 51 pp. 131-136, Oct. 2019.
- [13] W. Brand-Williams, M. E. Cuvelier, and C. Berset, "Use of free radical method to evaluate antioxidant activity," *LWT-Food Science and Technology*, vol. 28, pp. 25-30, Jan. 1995.
- [14] K. Kampfinkel, M. V. Montagu, and D. Inzé, "Extraction and determination of ascorbate e dehydroascorbate from plant tissue," *Analytical Chemistry*, vol. 225, pp. 165-167, Feb. 1995.
- [15] E. Degl'Innocenti, L. Guidi, A. Pardossi, and F. Tognoni, "Biochemical study of leaf browning in minimally processed leaves of lettuce (*Lactuca sativa* L. Var. Acephala)," *Journal of Agriculture and Food Chemistry*, vol. 53, pp. 9980-9984, Dec. 2005.
- [16] R. B. Tobias, C. D. Boyer, and J. C. Shannon, "Alterations in carbohydrate intermediates in the endosperm of starch-deficient maize (*Zea mays* L.) Genotypes," *Plant Physiology*, vol. 99, pp. 146-152, May 1992
- [17] T. Murashige and F. Skoog, "A revised medium for rapid growth and bioassays with tobacco tissue cultures," *Physiologia Plantarum*, vol. 15, pp. 473-497, Jul. 1962.
- [18] C. Sangavai and P. Chellapandi, "In vitro propagation of a tuberose plant (*Polianthes tuberosa* L.)," *Electronic Journal of Biology*, vol. 4, pp. 98-101, Jan. 2008.
- [19] K. L. Huang, I. Miyajima, H. Okubo, T. M. Shen, and T. S. Huang, "Flower colours and pigments in hybrid tuberose (*Polianthes*)," *Scientia Horticulture*, vol. 88, pp. 235-241, May 2001.
- [20] M. Grzeszczuk, A. Stefaniak, and A. Pachlowska, "Biological value of various edible flower species," *Acta Scientiarum Polonorum Hortorum Cultus*, vol. 15, pp. 109-119, Jan. 2016.
- [21] Regulation (EU) No 1169/2011 of the European Parliament and of the Council of 25 October 2011. In Daily Reference Intakes for Vitamins and Minerals (Adults); Annex XII; European Union: Bruxelles, Belgium, November 2011.
- [22] B. Najar, I. Marchioni, B. Ruffoni, A. Copetta, L. Pistelli, L. and Pistelli, "Volatile analysis of four edible flowers from *Agastache* Genus," *Molecules*, vol. 24, 4480, pp. 1-12, Dec. 2019
- [23] J. B. M. Custers and J. H. W. Bergervoet, "Differences between *Nerine* hybrids in micropropagation potential," *Scientia Horticulture*, vol. 52, pp. 247-256, Nov. 1992.
- [24] A. Meier-Dinkel, B. Becker, and D. Duckstein, "Micropropagation and ex vitro rooting of several clones of late-flushing *Quercus robur* L.," *Annals of Forest Science*, vol. 50, pp. 319s-322s, 1993.
- [25] B. Ruffoni, M. Airò G. Pascella, C. Mascarello, G. Zizzo, and C. Cervelli, "Rooting and acclimatization of ornamental myrtle genotypes" *Acta Horticulture*, vol. 616, pp. 255-258, Nov. 2003.
- [26] B. Ruffoni and M. Savona, "Physiological and biochemical analysis of growth abnormalities associated with plant tissue culture," *Horticulture, Environment, and Biotechnology*, vol. 54, pp. 191-205, Jul. 2013.

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Aramon and in 2015, in the national experimental program 'Process Approach for the Commercial Innovation in Cut Flowers, Leaves and Twigs' at the Alpes Maritimes Chamber of Agriculture. In 2017 she won an award for being in the top ten in a national competition 'Young Ideas for Innovation in Agriculture in Southern Italy' with the theme of edible flowers. The competition was organized by Rete Rurale Nazionale 2014/2020 and MIPAAF. Rosanna is currently working at the Alpes Maritimes Chamber of Agriculture in Nice, France, on the Interreg Alcotra ANTEA program: 'Edible Flowers: Innovations for the Development of a Cross-Border Sector.' Her current research interests are in the field of edible flowers, agronomy and aromatic and medicinal plants.



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