under the aegis of

ISHS

Harvesting the Sun Italy

a publication of the Italian Society for Horticultural Science

Harvesting the Sun Italy

Edited by *Stefania De Pascale, Paolo Inglese and Massimo Tagliavini*

a publication of the Italian Society for Horticultural Science

ISBN: 978-88-940276-5-5

Editors
Stefania De Pascale, Paolo Inglese and Massimo Tagliavini

Design and Layout
Francesca Massimi

Publisher
Italian Society for Horticultural Science - (Società di Ortoflorofrutticoltura Italiana - SOI)
Viale delle Idee, 30 - 50019 Sesto Fiorentino (Firenze)
e-mail: segreteria@soishs.org
website: http://www.soihs.it

Harvesting the Sun Italy has been published in agreement with ISHS, that is the publisher of the book named Harvesting the Sun (2012, ISBN 978 90 6605 704 3). Harvesting the Sun Italy is not a translation Harvesting the Sun, but includes original chapters that represent a picture of the Italian horticulture.

A web version of this publication is available at www.soihs.it .

Printed in Italy - January 2018

CONTENTS

CONTENTS

FOREWORD

In 2012, the International Society for Horticultural Science (ISHS) published a book in the *Scripta* Series called *Harvesting the Sun*, *a profile of World Horticulture*. It aimed to shed light on world horticulture and inspire readers to work for a positive future. The book was intended for the general public, policy makers, politicians and the press, to showcase the importance of horticulture and research in horticulture in the world. The overall objective of the book was to make progress in responding to the question '*What is Horticulture all about*?'

For centuries, horticulture was considered to be the cultivation of gardens, orchards or nurseries to produce fruits, vegetables and herbs, mainly for seasonal and local consumption. Basically, only spices were traded extensively. Then, different plant species were increasingly collected to create beautiful botanical gardens, giving rise to the use of orangeries. Later, the productions of flowers, fruits, vegetables, ornamental plants and herbs became an important commercial activity that spread all over the world. In turn, the development of postharvest technologies to preserve this often delicate perishable produce increased.

Toward the new millennium, the role of horticulture has become more comprehensive, including different and specific disciplines: Floriculture, Landscape horticulture, Olericulture, Pomology, Postharvest physiology. Consequently, a wide range of plant products and other living materials are part of horticulture: food crops, such as fruits, vegetables, nuts, seeds, herbs, medicinal plants, sprouts, mushrooms, algae, flowers, seaweeds; crops for processing and/or extraction, such as olives, hops, grapes, tea, coffee, herbs and medicinal plants; non-food crops, such as grass and ornamental herbaceous plants, shrubs and trees.

What is most important, however, is that in the third millennium horticulture's important roles in society have finally been recognized; it provides services such as plant conservation, landscape restoration, landscape and garden design, construction and maintenance, and horticultural therapy. This wide range of food, medicinal, environmental and social products and services are all fundamental to developing and maintaining human health and well-being. Edible horticultural products are not only nutritious, but also protectant, i.e. they prevent many of modern society's diseases.

Today's state-of-the-art technologies offer several prospects to society: advanced production techniques, such as protected cultivation systems, water-circulated irrigation systems, plants resistant to pests and diseases, grafting techniques, etc., allow for high productivity and save resources; advanced postharvest technologies let produce be preserved from harvest to consumers, keeping products safe and maintaining their organoleptic quality if they are edible, or maintaining their beautiful appearance if they are cut flowers; modern handling systems, where automation and logistics let us maintain plants in good physiological condition prior to being planted in fields or public and private gardens. Today's knowledge allows us to produce products with a higher quality and commercial value than those of the past.

Indeed, today the horticulture industry must cope with high demands from modern consumers. Food products are expected to be available all year round and to everybody around the world, serving a potential 8-9 billion people in the near future with good, safe, tasty and nutritious products. Ornamental species are not only required to provide nice and long lasting flowers and garden plants as well as beautiful urban and rural landscapes, but also to meet landscape ecology and urban horticulture needs.

Today, the horticulture industry must help increasingly urbanized communities: more than 50% of the world population lives in urban areas where fresh horticultural products and pleasant landscapes are vital to their wellbeing.

All of the actors in the chain, from the producers, processors, logistic departments, distributors, stores, as well as the stakeholders and consumers, must come together and help reduce food waste: from food loss, occurring at production and processing points, to the food waste occurring at distribution points. The horticultural industry must also produce its products in an environment that is healthy for the workers and through economically, environmentally

and socially sustainable means. Smart horticulture must be used to face the today's big challenges: saving natural resources, using them efficiently, and even reusing them safely, and also protecting the environment. Researchers are providing several tools to succeed in facing these modern challenges. Examples encompass developing new plant varieties that are resistant to abiotic and biotic stresses, that bear fruit with a better taste or shape, or simply widening the array of colors and shapes of our food or our gardens; using biotechnologies to ameliorate plants adapted to climate changes; controlling agricultural inputs for rational fertilization and irrigation and practices; studying systems to constantly monitor plant growth and development for its highly efficient production; unrevealing plant metabolisms and biochemical pathways that drive the syntheses of bioactive molecules for enriching our diet; testing natural preservatives, technological aids, processing operations for making our food or flowers last longer with good quality in our households.

Where does Italy stand in horticulture? The present book, *Harvesting the Sun Italy*, follows up from the original *Harvesting the Sun*, *a profile of World Horticulture*, presenting Horticulture in Italy, with nine chapters that show the country's primary industry at its best, from its genetic resources to its advanced fruit and vegetables crops and nurseries, to the beautiful Italian horticultural landscape. From available postharvest technologies to social horticulture, the book emphasizes questions of health and wellbeing but also looks at the future, in space, thanks to Italy's contribution to this field of research. The book does not forget the researchers, practitioners and stakeholders working in the country for a positive future. *Harvesting the Sun Italy* is the results of an initiative of the Italian Society for Horticultural Science (Società di Ortoflorofrutticoltura Italiana, SOI), a national scientific society constituted in 1953, six years before the formal constitution of the ISHS, and thanks to the common effort made by many Italian researchers. It is a great honor for me, Vice President of the ISHS as well as an Italian, to have the opportunity to write the preface to this book. I hope it will be read and used by a wide audience around the world and will be the first of a long series of *Harvesting the Sun* editions that present other countries. We all need to promote the importance of horticulture and horticultural science.

Prof. Silvana Nicola
Vice-President and Vice-Chairperson of the Board of Directors of the
International Society for Horticultural Science (ISHS)

PREFACE

After the International Society for Horticultural Science (ISHS) published the book "Harvesting the Sun, a Profile of World Horticulture" in 2012, the Italian Society for Horticultural Science (SOI) realized that it was time to present an updated view of the many features of the national horticultural system to an international audience.
"Harvesting the Sun Italy", developed under the aegis of the ISHS, outlines the fundamental characteristics of Italian horticulture: from field production (chapters 1 and 2) to the huge agrobiodiversity derived from its long tradition and variety of different growing environments (chapter 3), to its role in shaping the landscape of the Italian Peninsula (chapter 4), to the post-harvest supply chain (chapter 5), to the people that make it possible (chapter 6), to its contribution to human wellbeing (chapter 7), to future scenarios that have their roots in the past (chapter 8). The books ends with a chapter that summarizes the history and the main activities of the Italian Society for Horticultural Science (*http://www.soihs.it/aboutus.aspx*), which has been one of the most active national horticultural societies worldwide since its foundation in 1953 and whose members have continued to play pivotal roles within the international community.

Thanks to the importance of horticulture in Italy, our country has been called "Italus Hortus" since the Roman age, when the title was used to describe the beauty of the Italian horticultural landscape. "Italus Hortus" is also the title "SOI" has chosen to name its scientific Journal, now largely available in an open access format at *http://www.soihs.it/italushortus/english.aspx*. Italy holds a treasure in terms of biodiversity, tradition, and historical landscapes, which coexist with technological innovations. There is no single village in the country without a particular agricultural and food tradition. Indeed, horticultural products are at the heart of Italy's renowned gastronomy.

This book seeks to honor this tradition as well as to show the role innovation plays in making Italian horticulture an important asset for the national agricultural sector. We dedicate the book to all of the figures that contribute to the success of national horticulture with their efforts, risks, enthusiasm and creativity, including: growers and producer boards, advisors, nurserymen, companies providing goods and services, processing industries, educators and scientists.

This book is the result of the cooperative effort of a team of members of the Italian Society for Horticultural Science who have provided their voluntary contributions: we would like to thank all of them. A special thanks to Francesca Massimi, who was in charge of the book layout and design, and to Cassandra Funsten who has polished the text's English. We are extremely glad that ISHS welcomed this initiative, gave it its aegis and offered to write the Foreword to this book.

The Italian Society for Horticultural Science hopes that this volume will be appreciated by both specialists as well as by a more general public. We, the editors, are confident you will enjoy reading it.

Stefania De Pascale, Paolo Inglese and Massimo Tagliavini

CHAPTER ONE

THE FRUIT INDUSTRY

S.Sansavini, D. Neri, F. Famiani, O. Silvestroni, L. Catalano, M. Tagliavini

Italy has one of Europe's most varied and wide-ranging fruit industries, dating back to ancient Rome. Olives, grapevines, figs, apples, pears, almonds, plums and many other fruits already present in the hortus of the Roman villa, were then grown in monastic gardens and have survived until today.

The long Italian peninsula stretches from the 37° N to the 46° N parallel, for over 1300 km through a variety of environments; from sea level to elevations of more than 1,500 m asl in the Southern part and over 1,000 m asl in the Northern part. About 40% of the country's total land area (301,263 km^2) is made up of hills, 39% of mountains and only 21% are plains. These conditions are favourable to tree crops: in fact, 25% of the total agricultural income originates from perennial woody fruit crops, among which viticulture makes up about 35-40% of the total.

Figure 1 - Overhead irrigation system to control spring frost (top) and ice around the apple flowers (bottom).

The climate where Italian fruit production takes place is generally temperate (Type C of the Köppen-Geiger climate classification). Most fruit production in South and Central Italy (especially close to the coastal areas) falls within the Mediterranean climatic zone (temperate climate with dry and warm summers, Type CSa/CSb). Humid temperate climates (Types CF) are present in the production areas of northern Italy where deciduous fruit species are grown. In the Po Valley, which is especially important for stone fruit species and kiwifruit, the summers are warm and dry, while in the upper part of the Adige Valley, where the majority of Italian apples are produced, summer temperatures are milder and rainfall occurs more evenly throughout the year. Coastal areas of Sicily, southern Sardinia and Calabria have an arid climate (Type BS), while mountainous production areas (small fruits) sometimes fall within continental (boreal) climatic areas (Type DFb).

The main environmental constraints to fruit production include problems reaching winter chill requirements when deciduous fruit trees are grown in Southern Italy, sunburn damage on fruit skin and late frost risks in early spring, for example for apricots and peaches in the Po Valley and for apples in Trentino-South Tyrol (*Fig. 1*).

Main production areas differ in their soil characteristics including their depth, texture, pH and calcium

carbonate content. Traditional areas for cherry production in the Municipality of Vignola (Province of Modena) are, for instance, typically on deep soils, while apple orchards in mountainous areas as well as some of the vineyards in Tuscany are on relatively shallow soils. Pear orchards in the Provinces of Ferrara, Modena and Bologna are often planted on relatively heavy soils with a high clay content. In the eastern Po Valley, the soils are alkaline with various levels of calcium carbonate. Calcareous soils are also frequent in the Puglia Region, one of the leading Regions for fruit production.

The average farm acreage is around 10 ha, but it varies from less than 5 ha to more than 50 ha. Many small farms belong to grower cooperatives, which are often merged in big groups or consortia. The share of the Horticultural Value of the Italian cooperative system is around 8 billion euro, corresponding to 25% of the total horticultural product of the country.

Fruit Consumption, Import-Export

Fruit is an integral part of the national diet, consumed at table rather than between meals. Per capita consumption currently stands at around 80 kg/yr. of fruit, including 36 kg/yr. fresh fruits (mainly stone and pome fruits, and kiwifruits), 18 kg/yr. of citrus, 9 kg/yr. of exotic fruits, 1 kg/yr. of nuts, 1 kg/yr. of dried fruits, with another 15 kg/yr. of processed and frozen fruits. Pome and stone fruits, and kiwifruit are the most important group followed citruses (source CSO, Cfk, IRI Infoscan Census) and others. The widespread use of storage techniques, from pre-cooling to controlled, modified and dynamic atmospheres, has extended the market of apples, pears, peaches, nectarines, kiwis, cherries, apricots, citruses and grapes. Olive oil and table olives are largely consumed (about 12.8 and 2.3 kg per year and per person, respectively, estimated from IOC data).

Wine consumption is stable or slightly diminishing in the last decade, ranging from 45 to 60 l/ person/year, depending on the region. Young people drink much less then middle age and older adults. However, the slow fall of internal wine consumption corresponds a constant rise of its export, achieving in 2016 a total value of 5 billion euro. There is an increasing export of well-known sparkling wines (e.g. Prosecco) and of semi-sparkling wines (e.g. Lambrusco) as well as many other excellent red and white Italian wines.

Greengrocers are found everywhere, with an assortment and quality of produce that would be hard to match anywhere else in Europe. In Italy, the large stores and supermarket chains control about 58% of the market (GFK data), in comparison to 80-85% in the central and northern European countries. This helps keep consumption high, but also contributes to the high costs related to distribution.

Italy is a fruit exporting country with peaks of more than 3 million tons per year (mainly apples, kiwifruit, peaches, pears and table grapes). Italy also imports several fruit commodities, including olives, chestnuts and walnuts (ISMEA-ISTAT – 2008-2012) and especially bananas (more than 10 kg per year per person).

Fruit Production and Environmental Aspects

In the last few decades, increasing attention has been given to improving the ecological sustainability of the production process. Actions have been taken to reduce energy use and the C footprint of fruit commodities, to increase the efficiency of how limited resources are used, to maintain or improve soil fertility and to minimize nutrient losses and pesticide residues in the atmosphere and water bodies. In important fruit growing areas, integrated pest management (IPM) has been increasingly adopted by growers and will become compulsory starting in 2018: for instance, in the Emilia Romagna Region

around 85% of the vineyards and peach orchards follow integrated pest management guidelines, while more than 95% of the apple orchards in Trentino - South Tyrol are managed according to integrated fruit production guidelines and about 7 % are grown organically. Organic certified fruits initially claimed a market niche, but now tend to permeate all markets, constantly increasing its volumes significantly each year. Organic fruit production comprises, on average, 4-8% of total fruit production. Only organic olives and citruses amount to around 15-20% of the total production.

The increasing use of integrated pest management methods in fruit and olive orchards and vineyards has significantly contributed to the overall reduction (20%) of plant protection products used in the last ten years in Italian agriculture. The EU action plan for the sustainable use of plant protection products that recently came into force in Italian law is expected to produce further advancements in the development of environmentally friendly production systems.

Soil management with green covers is particularly important in hilly orchards to prevent soil erosion. The ability of fruit ecosystems to store, at least temporarily, atmospheric C in the soil and in woody biomass has been demonstrated for both deciduous and evergreen species. Some fruit producer associations, both in the North and in South of Italy, have already certified their C-footprint and energy use in the production system through the Environmental Product Declaration (EPD®).

Crop Management

The introduction of dwarfing techniques, such as summer pruning, drip irrigation, dwarfing rootstocks and compact and spur trees has resulted in important developments in spacing. Densities have increased so that 800 – 1,200 trees/ha are now fairly common for stone fruits and 2,000 – 4,000 trees/ha for apples and pears. Apple orchards of 3,000 – 5,000 trees/ha can now be found in the less fertile and shallower Alpine soils; in the South, even olives and walnuts are planted at over 500 - 800 trees/ha and hazelnuts are still around 400-500 trees/ha. High-density olive orchards with 2,000 trees/ha have recently been introduced together with a new mechanized tree management strategy, similar to that used for grapevines.

In high-density plantings, trees have shorter economic life spans – ten-twelve years for peaches, and fifteen-twenty for pears and apples. The aim is to reduce costs by managing trees from the ground. Training systems have also changed greatly, but almost all lead to a continuous, uniform hedgerow. The central-leader model with short laterals, a slender spindle or columnar axis, prevails for pome fruit trees. In young trees, very limited pruning enhances flower differentiation, but adults require a more balanced pruning and flower or fruit thinning to improve fruit colour, size, quality, and to controlling growth in the summer.

Vase, bush or palmette, columnar axis, or free shapes are the most commonly used training systems for stone fruits (*Fig. 2*). These species, are harder to train via the central axis alone, have in general a natural free shape that can gradually be either tailored to a hedgerow or become an expanded canopy (such as a "delayed open centre") by cutting the central leader to 100 – 140 cm high at the end of the third year. For peaches, the Catalane vase has recently been introduced, which is shaped with the use of mechanical summer topping. For the latter shape, blade machinery is normally

Figure 2 – Peach trees trained as central axis to create a continuous fruiting wall.

used a couple of times in Spring-Summer, at least in southern Italy. Free shaped "globes" and irregular vases are quite common for cherries and apricots. The spread of very high densities has slowed because of the risk of quality decline in adult trees due to shading and pruning difficulties. The high-density Y-trellis is also popular for its high yields, although it requires costly supports and more summer pruning. These orchards must be managed with the utmost care.

With the exception of olive plantations, which are irrigated only in about 12% of the total acreage (IAC – 2010), a significant fraction of orchards and grape vineyards are irrigated. The irrigated orchard acreage has increased by 35% in the last 30 years and about 600,000 ha of fruit tree plantations (also including grapes, citruses and olives) are irrigated. In the principal northern and southern areas, almost 100% of the newest orchards are irrigated. About 80% of the total acreage uses micro-irrigation systems (this is also the case for irrigated olive orchards), with annual average water volumes ranging from less than 200 mm for grapes to more than 500 mm for Citrus orchards. Overhead sprinkling prevents spring frosts in northern areas. Many growers today rely on meteorological data (i.e. evapotranspiration) and computer forecasting models provided by extension services to determine the timing and the amount of irrigation water, daily or weekly.

Significant advancements have also been made in determining correct fertilisation strategies based on soil and plant mineral analysis. The rates of nitrogen supply are often below 100 kg /ha; rates of potassium supply depend on the specific crops and the expected yields; phosphorus-based fertilisers are not often supplied as this element many soils are already well endowed. By contrast, organic matter, which has been administered in the form of manure, is being increasingly provided by compost and other organic compounds supplemented by processed waste of food processing plants.

The Main Crops

Italy is the leading European producer of pears, apricots, cherries, kiwis, lemons, and hazelnuts (*Tab.s 1 and 2*). It is also the second leading producer of apples, peaches, olives, grapevines, oranges, and almonds.

Crop	European rank	Surface (10^3 ha)	Yield (10^3 t)	Import (10^3 t)	Export (10^3 t)
Apple	2	55.0	2454.1	39.6	944.7
Apricot	1	19.1	222.7	28.1	25.3
Cherry	1	29.8	110.8	9.6	5.7
Kiwi	1	25.1	483.3	45.6	343.1
Peach	2	50.6	859.9	58.0	79.5
Nectarines	1	23.9	519.5	39.2	183.0
Pear	1	33.3	758.4	102.6	171.3
Plum	3	13.6	214.9	7.4	59.7
Table grape	1	47.8	1037.7	21.1	440.5
Wine grape (1)	2	662.8	5856.6	0.6	8.0
Olive (2)	2	1141.3	1925.3	7.5	2.1
Citrus					
Orange	2	88.3	1704.5	158.0	118.6
Lemon	1	25.7	382.8	90.9	44.1
Clementine & Mandarines	2	36.1	810.3	76.5	88.6
Nut					
Almond (with shell)	2	54.8	74.0	1.8	0.5
Hazelnut (with shell)	1	72.1	75.5	1.1	1.2
Walnut (with shell)	11			3.5	1.0
Strawberry	7	5.7	135.1	43.9	15.5
Total		**2385.0**	**17625.2**	**734.9**	**2532.3**

Table 1 - Italian fruit crop and acreage (2014) - Source: CSO-Ferrara, from Istat (Italian statistical service).

(1) Produced wine = 41.03 10^6 hl.
(2) 2013 olive production = 3.08 10^6 t (including 87,800 t of table olive)
Olive oil produced in 2013 = 463,700 t.

	Apple	Apricot	Cherry	Kiwi	Peach	Nectarine	Pear	Plum	Strawberry	Grape	Olive	Citrus
Piedmont	141.4	12.8	1.7	84.4	61.9	73.2	23.7	28.0	2.2	348.3	0.1	0.0
Trentino South Tyrol	1625.0	0.7	1.5	1.9	0.0	0.0	1.0	0.7	5.8	146.8	1.5	0.0
Veneto	278.9	3.8	14.5	77.1	27.3	23.9	75.1	2.6	21.4	1044.5	0.5	0.0
Emilia Romagna	176.2	74.5	16.1	77.8	152.8	259.9	528.6	83.9	9.0	898.0	3.5	0.0
Tuscany	23.6	2.3	1.2	1.6	17.2	3.5	11.1	7.2	1.6	382.1	62.3	0.1
Latium	6.6	1.4	3.6	136.1	27.1	3.3	2.1	18.5	10.5	189.3	50.7	3.4
Campania	62.1	35.0	22.8	28.9	244.6	65.1	11.0	32.8	51.3	172.8	120.4	55.4
Apulia	3.9	13.8	37.8	2.2	58.0	13.2	5.1	6.4	0.3	1499.0	816.9	256.9
Basilicata	7.1	44.1	1.0	10.6	47.5	17.6	4.5	8.4	12.9	35.2	33.3	125.6
Calabria	6.9	10.5	2.9	42.4	47.6	27.6	4.3	2.3	6.7	49.4	471.4	934.4
Sicily	12.1	11.2	2.9	0.6	111.6	12.1	55.6	6.2	5.9	1050.5	195.4	1436.7
Others	110.1	12.6	4.9	19.4	64.2	19.9	36.5	17.7	7.5	1078.4	169.2	84.9
Total	2454.1	222.7	110.8	483.3	859.9	519.2	758.4	214.9	135.1	6894.4	1925.3	2897.2

Table 2 - Italy: regional fruit crops (2014) (10^3 t) - Source: CSO-Ferrara, from Istat (Italian statistical service).

Apples

Figure 3 - Apple orchard in Val Venosta, South Tyrol. (courtesy of W. Drahorad).

The main growing belt is the Alpine rim, mainly the Provinces of Trento and Bolzano (South Tyrol), where around 70% of the total amount of Italian apples are produced (*Fig. 3*). The Emilia-Romagna and Veneto regions (20% combined) have a pressing surplus problem, with a small percentage of yields delivered for June production (around 10%) withdrawn each year for alcohol distillation or juice production. The "Golden Delicious" and "Gala" clones are the dominant cultivars, followed by other polyclonal varieties, such as "Fuji", "Red Delicious", "Granny Smith", "Braeburn", "Jonagold", "Rome Beauty", "Stayman" and the recently introduced "Pink Lady"- Rosy Glow, "Kanzi" and "Pinova". Another dozen of new cultivars have been introduced with the "Club" contractors. Scab-resistant apples such as "Topaz", "Modì", "Crimson Crisp", "Golden Orange", "Goldrush", "Primiera" and several other new ones are expected to become more widespread in the near future ("Bonita", "Fujion", "Story"). "Annurca", from ancient Roman times, is still an important variety in the Campania region, while others, such as "Gelata", Rosa and "Appio", are still grown in marginal areas. In intensive orchards, M9 is by far the most popular polyclonal rootstock, followed by M26, M106 and M111 (the last one in marginal areas).

Apricots

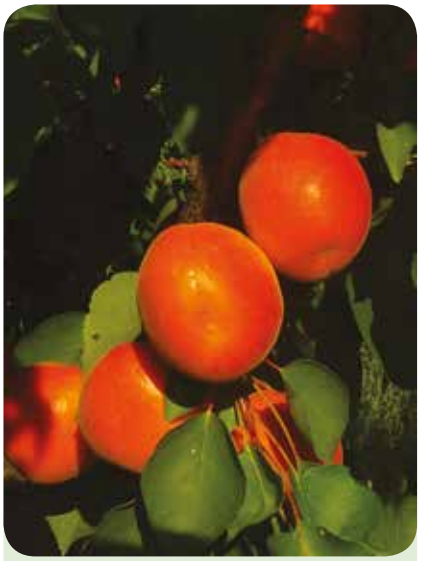


Figure 4 - Apricot fruiting branch in Emilia Romagna Region.

Demand for apricots is high both for the fresh market and the processing industry. The older Italian cultivars "Boccuccia", "Palummella", "Portici", and "San Castrese" cover a relatively constant acreage, especially near Naples and Caserta. The new dominant cultivars, after "Ninfa", "Bora", "Kioto", "Goldrich", "Lady Cot" spread several years ago but are now under pressure from mainly French international breeding programs that have released new varieties (i.e. "Big Red", "Spring Blush", "Farbaly" and "Farely") belonging to the "Carmingo" series and others like "Rubingo" (i.e. "Rubista" and "Rubely"), with firm flesh and a red skin colour (*Fig. 4*), expanding the season. Several of these don't have much flavour, but their impact on the market has been revolutionary. In the last few years, new apricot varieties from Italian public and private breeders have been introduced in districts that traditionally hosted peach trees, as a consequence of the peach market crisis (i.e. in Romagna and Piedmont).

Citruses

Figure 5 – Lemon flower and fruit.

Italy plays an important role among the world's leading Citrus producers. With its 150,000 ha of citrus species averaging around 3.0 million t of fruit per year, Italy ranks fourth among the world's leading countries. Sicily is the main citrus district, with an acreage of almost 100,000 ha and an average yearly production of 1.5 million t fruits, followed by Calabria. The Campania, Sardinia, Apulia and Basilicata regions have a much less extensive acreage and a far lower production. Oranges and mandarins are grown in Sicily, Calabria, Sardinia, Basilicata and Apulia; mandarins (Mediterranean mandarins, clementines and other citrus hybrids) are rapidly expanding in Calabria, Campania and Apulia; lemons in Sicily (92% of total) (*Fig. 5*), Campania and Calabria; minor fruits such as bergamot (grown for its essential oil), citron (used to candy the thick skin) and lemon-citron hybrids are found in Calabria. Citrus fruits are picked from early October through May-June, beginning with Naveline oranges and clementines and ending with late ripening Valencia oranges. The Sicilian red orange cv "Tarocco" is very popular because of its taste and richness in flavonoids; the famous brand of "Tarocco" is now a symbol of the Italian orange, and excellent quality. Other old red types of orange are "Moro" and "Sanguinello", known as the blond foreign oranges i.e. the "Navel" and "Valencia" clones account for less than 30% of the total. Most of the varieties have been reselected by an embryonic nucellar process that has led to a few dozen new orange, lemon and mandarin clones in a virus-free propagated line. New rootstocks such as Trifoliate orange and Citrange types have improved resistance to diseases, such as Tristeza, significantly reduced tree size and facilitated augmented planting density. Pleasant surprises have also come from the industrial processing sector, not only in the extraction of oils for high-quality perfumes, but especially in the last few years also in juice extraction.

Ongoing research in this field has developed physical treatment methods that stabilize the juice from blood oranges and allow its storage in ordinary refrigerators for enough time so that it maintains its freshness and homogeneous red colour. Given the fact that the juice vitamin content from "Tarocco" and other local cultivars is especially high, marketing should promote their consumption.

Cherries

Self-fertile Canadian (i.e. "Celeste", "Lapins", "New Moon", "Samba", "Sweet Hearth") as well as American and Italian cultivars such as "Van" and "Giorgia" are very interesting. There are many local sweet cherry cultivars praised for their quality. The Italian variety "Ferrovia" is by far the most widespread. Old local varieties, such as "Durone I and II di Vignola", have fruits with good flavour, firmness and colour, but fruit size and productivity are unsatisfactory. Several excellent new Italian self-fertile varieties have been introduced in the last few years (such as "Big Star", "Grace Star" and "Black Star", the "Sweet" series ("Gabriel", "Marysa", "Stephany", etc.); fruits are large, with nice colour, firm and sweet. They have generated a great deal of expectation and higher prices. Although traditionally grafted on relatively vigorous rootstocks, recently planted cherry orchards often benefit from the use of dwarf rootstocks (e.g. "Gisela" 5 and 6). Sour cherry cultivation is no longer economically viable, except for typical local production for niche markets.

Grapes

Figure 6 – Not irrigated vineyard for grape wine production in central Italy. Sangiovese and Montepulciano grapevines vertical shoot positioned.

Grapes are grown from the Alps to Sicily, from Friuli in the East to Piedmont in the West, from the mountain slopes to the seaside, with most wine grape vineyards being located on hillsides (*Fig. 6*). Although acreage has strongly declined in recent years, as well as wine consumption, Italian viticulture is still remarkable for its more than 600,000 hectares. The main regions for grapevine in terms of acreage are Sicily, Apulia, Veneto, Tuscany, Emilia-Romagna, Piedmont and Abruzzo. Most grapes (about 6.6 million t in total) are processed for wine production (from 40 to 50 million hl/yr). Some 20 million hl per year of wine have been exported over the last five years. A few hundred types of V.Q.P.R.D. (Quality wine produced in delimited regions) or premium wines of certified origin account for some 8-10 million hl, and their share is increasing. White wines, whose leading regions are, among others, Veneto, Friuli and Trentino-Alto Adige, accounts for about half the total. Red wine production is typical of Tuscany, Piedmont, Apulia and Abruzzo. Wine grapes represent an important horticulture sector in Italy, and cultivar decision-making is restricted by laws indicating which ones are admitted or recommended per province. For example, the French and German hybrids have not been permitted for commercial wines for a long time, however, due to new hybrids licensed by several scientific European institutions, some new resistant clones that produce excellent wine have recently obtained authorization.

The target is to achieve high quality and typical wines taking advantage of the different environments and cultivars: for example, noble red DOC wines with well known brands such as Barolo and Barbaresco in Piedmont, come from Nebbiolo. The famous Brunello di Montalcino, Chianti (Tuscany), and Sangiovese in Romagna are different brands of the same cultivar, Sangiovese, alone or mixed with other varieties. In other areas, some cultivars of international quality such as Cabernet Sauvignon and Merlot are grown, and Chardonnay and White and Grey Pinots have been widely introduced. For the semi-sparkling red wines, the most well known cultivars, especially in the United States, are Lambrusco (brand and variety names are the same, produced in Emilia) and Brachetto (produced in Asti province). For the Spumanti (sparkling wines) in general, some long-standing wineries are very active in Lombardia, as is the case with Franciacorta (Brescia), Oltrepò Pavese, in Veneto for the Valdobbiadene Prosecco and Trento areas. The sweet aromatic Asti DOC is traditionally obtained from white Muscat grapes (in Asti province). Some special sweet liquor-like wines include Marsala from Sicily, Vin Santo from Tuscany, Picolit from Friuli – Venice Giulia and Albana Dolce from Bertinoro, Romagna. Table grapes are planted in around 60,000 ha, and produce about 1.4 million t, 450,000 of which are exported. Table grapes are concentrated mainly south of the 42° parallel in 6 regions: Puglia (55%), Sicily (35%), Abruzzo (5%), Lazio (2%), Calabria and Basilicata. The leading cultivar for white table grapes is the share-surging "Italia" (now about 40-50% of the total), followed by "Victoria" with less than 10%, and then "Regina" (also known as "Bolgar", "Waltham Cross", "Rasaki") with about 5%; "Red Globe" covers more than 7%. Other seedless cultivars are now gaining importance, covering more than 50% of the new plantations: "Centennial", "Crimson Seedless", "Autumn Royal", "Regal" and many other new American cultivars. Another important sector here is grapevine propagation, which occupies 1,800 ha and involves 1,500 firms. Every year, some 50 million rooted plants of hybrid rootstock cuttings and 35 million grafted rooted plants are produced. The most commonly used rootstock clones in Italy are Berlandieri x Riparia (Kober 5 BB, and 420A), mainly used in the northern and central regions, and Berlandieri x Rupestris 140 Ruggeri, 1103 Paulsen and 779 Paulsen in the southern regions. Other leading rootstocks produced by Italian nurseries, which are also exported to foreign markets, are the clones SO4, 157.11, 125 AA, 225 Ru and 34 E.M.

Kiwifruits

The kiwi is the only successful new exotic species established in Italy in the last 40 years. In slightly more than two decades, its acreage has increased to 25,000 ha: one-third in Lazio, one fifth in Emilia-Romagna and the remainder in regions both in the north and in the south of Italy (Piedmont, Basilicata, Campania, Sicily), where it can suffer from winter and spring frost (north) and from wind, drought and salinity (south). So far, the kiwi has proved to be an excellent and stable cash crop, thanks to its excellent quality and the export market quota achieved despite some years of price decline. "Hayward" is the main commercially grown green cultivar; in vitro scion self-rooted is the prevalent propagation technique and rootstock D1 (selected in the Cesena area) is used in clay soils. The original New Zealand pollinator males are still used. A variety revolution recently started thanks to the yellow and red flesh types, introduced by China, New Zealand and Italian breeding programs at the Universities of Bologna and Udine. These are "Sun Gold" (Zespri), "Jingold", "Dorì", "Soreli", all yellows, and the Chinese red flesh "Hfr 18". Several other new varieties have recently been introduced.

Olives

Figure 7 – Olives of the cv. "Leccino " grown in Tuscany Region.

In the last Italian Agricultural Census (IAC - 2010), the entire olive acreage was 1,123,330 ha, which makes it the main fruit species cultivated in Italy. Almost all of the olive crop is used for oil extraction. Only about 1.2% (13,626 ha – IAC 2010) of the cultivated area is used for table olives, which amounts to about 65,100 t (International Olive Council - IOC). The Mediterranean Basin is still the dominant olive belt, with Italy accounting for about 10% of the world's 10 million ha. On average (FAOSTAT – 2009-2013), the olive production amounts to about 3,119,517 t per year from which about 520,247 t/year of olive oil were extracted. The amount of produced table olives (green and black) varies from 50 – 60,000 t. Olive cultivation is mainly concentrated in southern and central Italy. The main regions are Puglia (33.2% of total), Calabria (16.6%), Sicilia (12.6%), Toscana (8.2%), Campania (6.5%), Lazio (6.0%), Sardinia (3.2%) and Umbria (2.7%) As a result of the widespread distribution throughout several regions characterized by different soil and climatic conditions, Italy has a high number of olive cultivars. There are over 100 cultivars of agronomic importance, the most common being "Frantoio" and "Leccino" (*Fig. 7*). This fact, together with the high quality of the oil from both an organoleptic and a nutritional point of view, contributes to the reputation of excellence of Italian extra virgin olive oil. This has also contributed to the recognition of a number of certified productions (PDO, PGI*). In Italy there are more than 4,500 olive mills; this large number ensures rapid olive processing which contributesto the high quality of the oils produced. In addition to its importance for olive and oil production, in several cases the olive tree also makes an important contribution to the landscape and the protection of the environment (especially when cultivated on hills and mountainsides).

Peaches

Today, the peach industry is characterized by few dominant trends. Heading the list is the extended seasonality and the search for early and mid-late cultivars. The market is dominated by yellow varieties and there has been a surge in northern areas in the market share of nectarines to 60-70% of the total. The white peaches and white nectarines together cover only 10-15% of the total . Flat peaches and nectarines have gained new spaces in the last years. The demand is stable for canned peaches, which cover less than 10-12% of the product. Cling peaches are also utilized frequently for the fresh market in southern Italy. Many rootstocks can adapt peaches to less than optimum soils – the peach seedling peach x almond hybrid 677 predominates, followed by the wild peach seedlings and Prunus spp. groups, such as P. insititia (Adesoto) including French hybrids (like Isthara, P. persica x P. cerasifera). Generally, the chosen rootstocks must correspond to the soil conditions, such as replanting (for disease risks), lime excess, etc.

* PDO = Protected Designation of Origin; PGI = Protected Geographical Indication.
1 Recently, new fruit typologies have been spreading, especially those with modified flesh firmness, melting and taste: with reduction of acidity, increase of consistency and delay of ripening such as the stony-hard types. We should also mention the "platicarpa" flat peaches, which gained popularity following a trend initiated by Spain ("paraguayo" peaches) several years ago.

Pear

Combined, the lowlands of the Emilia-Romagna and Veneto regions produce over 75% of Italy's pears. The most widely grown cultivars are the autumn ripening "Abbé Fétel" and "Conference", followed by the summer cv "William" ("Bartlett") that is grown for both the fresh market and canning, while a new Italian summer variety, "Carmen", is now gaining market positions. Other important varieties are "Doyenné du Comice", "Beurré Bosc" and "Angelys", the latest winter variety.

The Japanese nashi varieties are gradually being abandoned after their initial introduction around 20 years ago. Some of the old local varieties still being grown including "Coscia" ("Ercolini"), "Spadona" ("Blanquilla" in Spain) and "Gentile" in southern Italy, "Madernassa" in Piedmont and "Winter Spadona" in the Alpine area.

The main rootstocks are the quince clone Sydo, followed by the dwarf clones MC Adams and MH. Other clones are MA and Provence BA29. Semi-dwarfing P. communis clones Farold 40-Daygon and Farold 69-Daynir are in great demand at the present, as well as the Fox series.

The use of self-rooting in vitro plants to eliminate the need for rootstocks is currently an option in lime soils and for varieties not compatible with quince (e.g. "Beurré Bosc" and "Bartlett").

Plums and prunes

The Sino-Japanese diploid hybrids with large fruits are successfully making inroads against P. domestica, which is still dominant only for dried fruits. Varieties such as "Angeleno", "Fortune" and "Black Gold" are well known.

New large and very attractive plums (hybrid Sino-Japanese – American) have recently been introduced, encouraged by market demand. The consequence is a reduced request for the traditional prune varieties (*P. domestica*), because most of them produce small fruits.

Prune drying and canning for industry have limited importance, although some Italian brands (i.e. "Monteré") have a good market reputation. Most of what Italy consumes comes from imported American and French dried prunes.

Strawberries

The northern growing belt has successfully introduced new varieties, leading to a continuous, rapid turnover. In southern Italy, the dominant cultivars are "Candonga", "Sabrina", "Safari" and "Tudla" and the American "Florida" - "Fortuna".

The new day-neutral cultivars tend to increase their market share and seasonality. Protected cultivation is quite widespread in Campania, Basilicata (Lucania) and Sicily. The most common Italian varieties in Northern Italy are "Clery", "Joly", "Garda", "Premy", "Marmolada", "Tecla", while "Antilla", "Asia", "Nabila", "Pircinque", "Jonica", "Naiad", "Rania" and the day neutrals "Capri" and "Ischia" are the mostly cultivated varieties in Southern Italy. However, many new varieties are introduced in the strawberry industry every year.

Nuts

Hazelnuts and almonds are the two most planted nut species (65,000 ha and more than 70,000 ha, respectively). Both take advantage of the change of crops induced in several southern areas where the peach industry has been partially abandoned due to a market crisis. Hazelnut is a traditional culture in numerous hilly areas, mainly in Piedmont, Lazio and Campania, where, a renewed interest raised the culture surface till 70,000 ha and the total filbert nuts till 110,000 t. This favourable trend is due to a world dramatic increase of consumption; the derived transformed products, like Nutella cream, contribute to the excellence of the "made in Italy" agrifood industry. Interest in walnuts is also growing, and new plantations are now spreading on irrigated soils in the North, as well in the South. In the past, all trees were grafted onto seedlings, but recently self-rooted micropropagated plants are becoming more requested. The chestnut is grown on about 25,000 ha, only in traditional hilly and mountainous areas. However, for economic and social reasons, it is difficult to find new plantations. Only part of the old restored plantations survives with satisfactory a crop.

The Nursery System

The volume of business of the Italian fruit nursery sector (without considering ornamental trees) amounts to more than 0.4 billion € per year (*Tab. 3*). Fruit tree nurseries cover over 5,000 ha and include around 28,000 employees. Grapevines plants are produced on 6,500 ha with around 6,000 employees.

For the propagation of fruit trees, the national volunteer certification system with a very high qualitative standard (virus tested or virus free) is applied to more than 228 million plants (including strawberries and artichokes) (*Tab. 4*). The European standard system CAC (Conformitas Agraria Communitatis), with a less strict control of plant quality, is applied to more than 135 million plants.

Stone fruit trees are mainly produced in Emilia Romagna and Apulia. Apple trees and pear trees are main propagated in Emilia Romagna and in Veneto. Citrus trees are mainly produced in Sicilia, Basilicata, Calabria and Sardinia. Olive nurseries are mainly located in Tuscany, Sicily, Calabria and Apulia. Grapevine nurseries (*Tab. 5*) are in Veneto, Marche, Apulia, Sicily and especially in Friuli Venezia Giulia.

The main types of commercialized trees are grafted scions and rootstocks (from micropropagation, stoolbeds and seeds). Olive cultivars are mainly self-rooted (by the cutting system) or grafted (on seedlings). In vitro micropropagation has a pivotal role in the production of rootstocks for stone fruit species and self-rooted varieties (berries and kiwifruits).

Currently, there are more than 20 commercial laboratories for micropropagation in Italy. In vitro techniques are also important for research purposes and for the improvement of propagation systems and breeding. Mini-grafting techniques, using in vitro - produced rootstocks and small buds from sylleptic shoots, have made it possible to reduce the production cycle for stone fruit trees to less than six months. Italian nurseries export significant amounts of their fruit trees and strawberry plant production. A significant example is the Consortium of South Tyrolean tree nurseries, which produces more than 10 million of apple trees per year, most of them for export.

Type of produces	Nurseries (number)	Values of the production (thousands €)	Values of the export (thousands €)	Acreage (ha)	Employees (number)
Ornamentals	3,000	1,300,000	520,000	16,000	80,000
Fruit trees	850	285,847	109,769	5,000	28,000
Grapevines	500	152,800	60,140	6,500	6,000
Total	**4,350**	**1,738,647**	**689,909**	**27,500**	**114,000**

Table 3 - Facts and figures of the Italian plant production system and export (source: ANVE, CIVI-Italia, MIVA and Associazione vivaisti viticoli Friuli Venezia Giulia, 2015).

Species	National Certified Plants (thousands)	CAC Certified Plants (thousands)	Total (thousands)	Price per plant (€)	Value (Thousands €)	Export (%)	Export value (thousands €)
Stone fruit	1,221	18,000	19,221	4.16	79,960	35	27,986
Pome fruit	4,941	22,000	26,941	4.00	107,766	35	37,718
Kiwi		2,500	2,500	2.50	6,250	30	1,875
Citrus	189	2,500	2,689	8.00	21,511	10	2,151
Olive	40	3,000	3,040	6.00	18,239	35	6,384
Other fruit species		1,500	1,500	4.00	6,000	30	1,800
Rootstocks (fruit species)	36,501	10,000	46,501	0.70	32,551	40	13,020
Strawberry	247,411	80,000	327,411	0.24	78,578	60	47,147
Othier berry fruits		2,500	2,500	1.10	2,750	70	1,925
Total	**290,304**	**143,500**	**433,804**		**355,106**		**140,006**

Table 4 – Values (€) of Italian fruit tree nursery production and export (source: CIVI-Italia 2017).

Type of produces	Certified Plants (thousands)	Price per plant (€)	Values (thousands €)	Export (%)	Values Export (thousands €)
Rootstocks	14,000	0.7	9,800	30	2,940
Grafted scions	130,000	1.1	143,000	40	57,200
Total	**144,000**		**152,800**		**60,140**

Table 5 - Values (€) of Italian grapevine nursery production and export (source: MIVA and Associazione vivaisti viticoli Friuli Venezia Giulia, 2015).

CHAPTER TWO

THE VEGETABLE AND ORNAMENTAL PLANT INDUSTRY

C. Nicoletto, G. Colla, P. Sambo, D. Romano

Vegetable Crops in Italy

The financial economic traits that characterized the horticultural supply chain in 2010 are summarized in ISMEA's (Istituto di Servizi per il Mercato Agricolo Alimentare) 2011 report (ISMEA, 2011): the horticultural chain generates a value of approximately 7.2 billion euro, equal to 16% of the total value generated by the entire national agricultural system; at the same time, the processing industry of horticultural products produces a turnover of around 5.7 billion euro (equal to 5% of the total turnover of the Italian agro-food system).

The system is characterized by an active trade balance (235 million euro). In the last few years, there has been a slight increase in the average farm size due to an increase in surface areas and to a diminishing number of companies, simultaneously there has also been a greater supply concentration due to the increased number of traders specialized in marketing vegetables. The annual production of vegetables, pulses and potatoes amounted on average to 15 million tons. In recent years, the annual production of vegetables showed strong fluctuations as a consequence of varying investments in the tomato industry and to difficult weather conditions. The production process is characterized by a very large number of farms with a really low average size. According to the VI Agriculture Census conducted by the Istituto nazionale di Statistica (ISTAT) in 2010, the Used Agricultural Area (UAA) amounted to 12.85 million hectares; about 3.65% of the UAA is devoted to vegetable crops and the number of companies is around 199.000, (*Tab. 1*). Therefore, the average farm size is 2.36 ha.

Vegetable crops	Cultivated areas (ha)	Number of farms
Peas	19,753	7,583
Dry bean	3,283	7,326
Bean	70,891	20,313
Lupine	2,940	1,056
Other pulses	42,270	8,919
Potato	27,114	29,220
Open field vegetable crops	266,737	99,130
Protected vegetable crops	32,944	22,391
Vegetable nursery plants	3,049	2,876
Total	**468,981**	**198,814**

Table 1 – Cultivated areas and number of vegetable farms in Italy (ISTAT, 2010).

Deepening the analysis of cultivated areas and companies, ISTAT divides open-field vegetable production into five subcategories: 1) fresh-market tomatoes; 2) processing tomatoes; 3) other vegetable crops; 4) fresh-market tomatoes in commercial gardens; 5) other vegetables in commercial gardens. Protected vegetable crops are divided into three subcategories: 1) fresh-market tomatoes; 2) other vegetable crops in greenhouses; 3) other protected vegetable crops (e.g. under tunnels, etc.) (*Tab. 2*).

There are also substantial differences among the various regions; in Northern and Central Italy, the farmer associations are more widespread, whereas in the south of Italy the production systems are

characterized by a low aggregation of farmers into cooperatives and producer organizations that consequentially have little negotiating power in the supply chain.

Open field vegetable crops	Cultivated areas (ha)	Number of farms
Open field table tomato	7233	18323
Open field processing tomato	76835	9564
Other open field vegetable crops	153950	74059
Table tomato in market gardens	931	1209
Other vegetable in market gardens	27785	13841
Protected vegetable crops	**Cultivated areas (ha)**	**Number of farms**
Greenhouse table tomato	6732	7464
Other greenhouse vegetable crops	17161	14730
Greenhouse-tunnel vegetable crops	9050	3846

Table 2 – Cultivated areas and number of vegetable farms in Italy (ISTAT, 2010).

Organic Vegetable Production

The VI Agricultural Census (ISTAT, 2010) also provides data about the number of farms that use organic production methods (*Tab. 3*).

	Partially organic area		Totally organic area	
Crops	Number of farms	Cultivated areas (ha)	Number of farms	Cultivated areas (ha)
Dry legumes	2430	23774	961	10609
Potato	1041	1325	433	509
Vegetables	3763	16216	1836	8460
Total	**7234**	**38315**	**3230**	**19578**

Table 3 – Cultivated areas and number of vegetable farms in Italy (ISTAT, 2010).

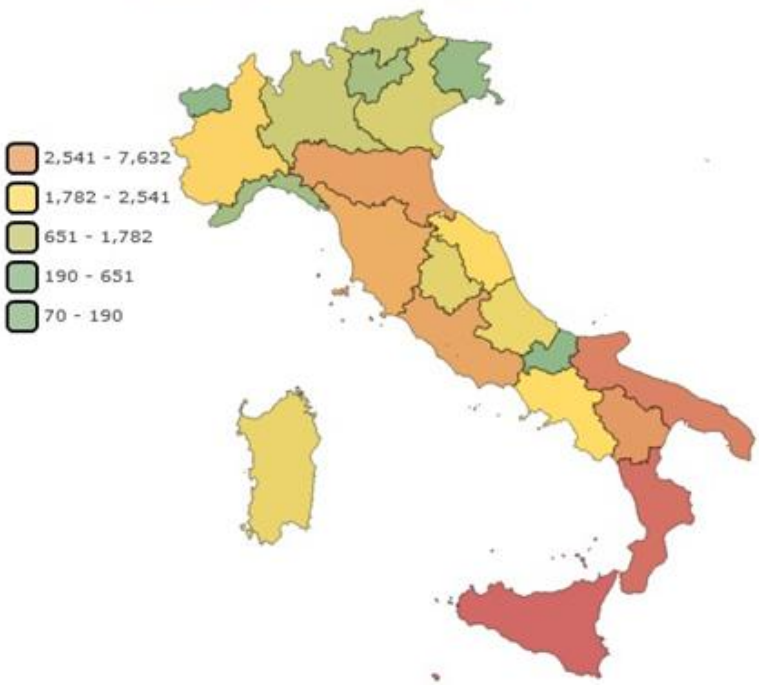


Figure 1 – Distribution of organic farms in Italy (ISTAT, 2010).

The distribution of organic farms at a national level, according to ISTAT (2010), is completely different among regions. The regions with the highest number of organic farms are mainly located in the south and central Italy, especially in Sicily, Calabria and Puglia. North Italy, on the other hand, is mainly characterized by conventional and low input farms (*Fig. 1*). The surface area used for organic vegetable production compared to the total surface area for organic crop production is limited to just

a few percentage points. Most of the land used for organic agriculture is used for growing cereals, olive trees and for pasture.

Finally, among the different organically grown vegetables, the importance of fruit vegetable crops (especially tomatoes) and legumes (peas) are clear, representing respectively 22% and 36% of the total surface used for growing vegetable crops under an organic regime (*Tab. 4*).

	In conversion (ha)	Organic (ha)	Total (ha)
Vegetables, melon, strawberry, cultivated mushrooms	3.457	17.879	21.336
Brassica	249	1.437	1.686
cauliflower and broccoli	107	808	914
cabbage	14	344	358
others	128	285	413
Leafy and/or stem vegetables	745	2.889	3.634
celery	5	67	72
leek	7	74	81
lattuce	52	141	193
endive	30	122	151
spinach	59	299	358
asparagus	80	451	531
cichory	7	119	127
artichokes	253	509	761
others	252	1.107	1.360
Fruit vegetables	651	4.152	4.803
tomato	238	1.850	2.087
cucumber	3	46	49
melon	73	378	451
watermelon	66	188	254
others	271	1.690	1.961
Root and bulb vegetables	152	1.324	1.476
carots	75	677	752
garlic	10	161	171
onion	31	239	270
shallot	0	3	3
others	35	244	279
Legumes	1.166	6.485	7.651
peas	686	2.802	3.487
bean	35	445	479
others	446	3.238	3.684
other vegetables	465	1.442	1.907
strawberry	19	118	137
cultivated mushrooms	11	32	43

Table 4 – Cultivated area and organically grown vegetable crops in Italy (ISMEA-SINAB, 2012).

The Greenhouse Industry

The use of covering systems to protect vegetable crops from adverse climate conditions is a fairly widespread practice globally. In fact, 700,000 hectares of greenhouses are estimated to exist, reaching more than 2 million hectares if we consider the total surface of protected cultivation in the World. China is the most important country with about only 1 million hectares of protected cultivation. One other important area of protected cultivation is the Mediterranean basin, with about 150,000 hectares of greenhouses. Italy, according to the 6th ISTAT Census, had a greenhouse-covered area greater than 40,000 ha, of which 35,000 are used for growing vegetable crops and more than 5,000 for growing flower and ornamental crops.

In Italy, the protected cultivation areas are characterized by low-tech structures usually covered by plastic films; a limited use of microclimate control systems quite often leading to suboptimal growing conditions for the crops (e.g., insufficient light intensity, poor ventilation, extreme temperatures); a high labor demand; a limited availability of good-quality water.

Low-tech greenhouses are especially used for growing vegetable crops (*Fig. 2*) while more sofisticated greenhouses (eg., heated greenhouses) are used for producing flowers and growing ornamental plants (*Fig. 3*). The widespread use of low tech greenhouses for vegetable production is due to the mild climatic conditions which allow the succesful cultivation of vegetable crops for most of the year in unheated greenhouses and tunnels covered with plastic film. The most recent statistics show that about 90% of the greenhouses are unheated and covered with plastic materials (e.g., films, panels), and only 20% are covered with glass and heated for floriculture and nursery activities.

Figure 2 - Low-tech greenhouses mainly used for growing vegetable crops.

Figure 3 – High-tech greenhouses and glasshouses used for growing ornamental plants and high value crops.

As reported in *Fig. 4*, about 56% of the whole Italian greenhouse surface area is located in the South of Italy, especially in the coastal areas. The farms that deal with crop production in greenhouses amounted to 31,256 compared to a total of 107,118 farms growing vegetable crops under open field conditions. From an economic point of view, protected cultivation generates wealth that far exceeds that of open field production systems. Overall, although the chain of greenhouse systems accounts for only 3.2% of the UAA, greenhouse cultivation created a business exceeding three billion euros considering structures, equipment, and inputs for plant production.

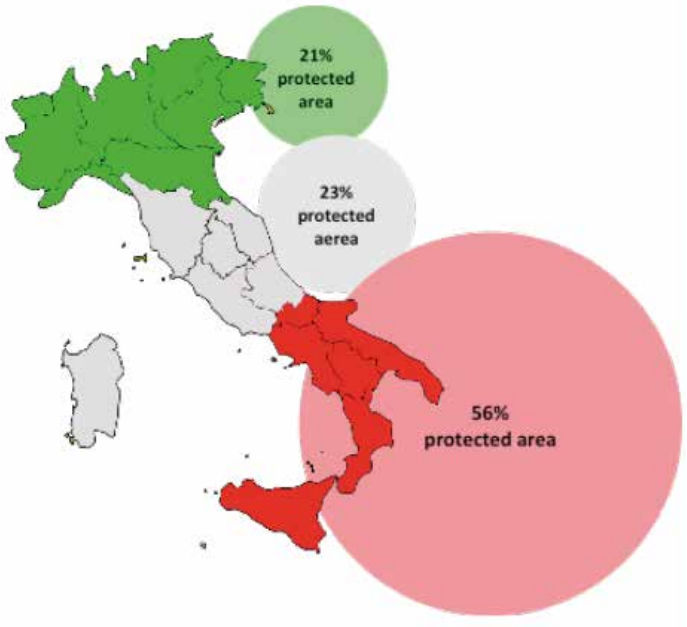


Figure 4 - Distribution of protected cultivation areas in Italy. Source: ISTAT 2015.

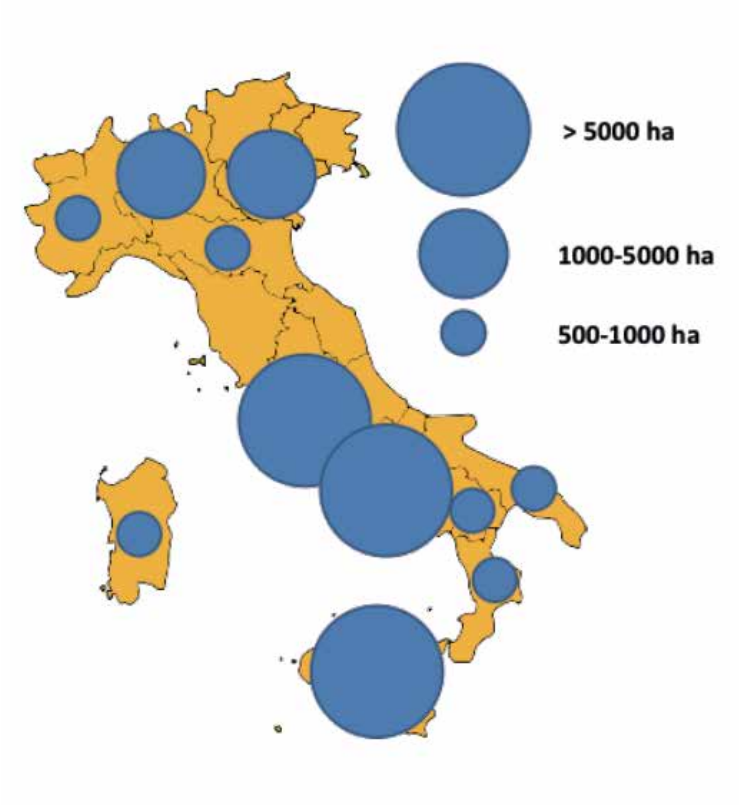


Figure 5 – Vegetable crop production under greenhouses and tunnels in different Italian regions. Source: ISTAT 2015.

The distribution of greenhouse cultivation is spread over the entire peninsula with a greater concentration in Sicily, Campania, Lazio, Veneto, and Lombardy (*Fig. 5*).

Vegetable crop production in greenhouses covers about 5% of the whole vegetable cultivation area and over 65% of the area under protected cultivation. The vegetable crops mostly cultivated in greenhouses are (in decreasing order of importance): tomatoes, zucchini, lettuce, melons, strawberries, peppers, watermelons, eggplants, and asparagus.

These crops cover 76% of the Italian greenhouse surface area while, tomatoes alone, cover 20% the Italian greenhouse surface area (*Fig. 6*).

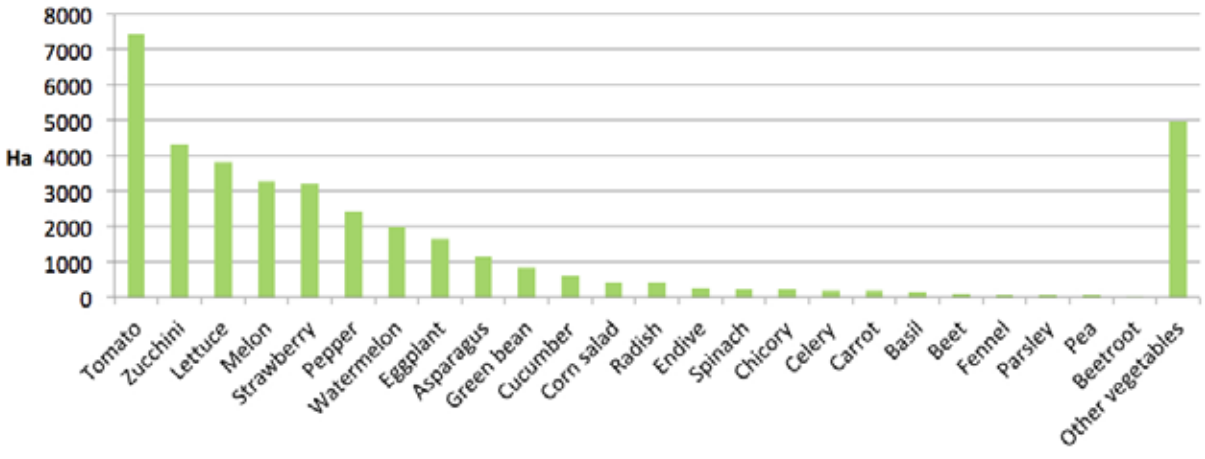


Figure 6 – Estimated protected area (hectares) for the most important vegetable crops in Italy.

Vegetable Transplant Production

The Greenhouse production of vegetable transplants is an important segment of the Italian vegetable production chain. With few exceptions, such as carrots, baby leaf vegetables, and some Brassicaceae, nearly all vegetable crops are transplanted due to the advantages of planting transplants compared to direct seeding. Nursery production is usually located in the main vegetable production areas (e.g. provinces of Ragusa, Latina, and Battipaglia) to satisfy the high demands of transplants from professional growers and in urban and peri-urban areas for hobby farming. Most of the vegetable transplants produced by Italian nurseries are sold at the national level while only a few big nurseries produce transplants for export to neighboring Countries (e.g. France, Greece). Nursery farms are highly specialized and mechanized, and often have advanced technologies for microclimate control. In many nurseries, vegetable grafting has become a common propagation technique for Solanaceous crops and Cucurbits due to the increasing grower demand of resistant plants to (a) biotic stresses and the growing restrictions of pesticide use. Rigorous quality control procedures and full traceability during the whole production process are adopted to guarantee the high quality of transplants for export and domestic markets.

Vegetable Production

Vegetables are commonly produced under low technology structures, such as single plastic greenhouses or high tunnels. The majority of greenhouses are unheated; excess air temperatures are controlled by natural ventilation, using continuous openings and providing shade curtains or by applying a coat of white paint. Vegetable crops are most often grown in soil using short-term intensive rotations. Fertigation and integrated pest management are commonly used for producing high-quality vegetables in an environmentally friendly way. Recently, there has been increasing interest in the use of floating systems for producing leafy vegetables and substrate culture for growing fruit crops such as tomatoes and cucumbers due to the difficulties in controlling soil-borne pathogens and nematodes, and the restrictions on the use of agro-chemicals. Organic vegetable greenhouse production represents less than 1% of the total greenhouse vegetable area. Because of the limited arable land and the growing demand for high quality vegetables from environmentally friendly production systems, the use of sustainable intensification practices in the greenhouse vegetable industry is expected to increase. Rigorous quality control procedures and full traceability during the whole production process are adopted to meet the rising quality and safety requirements of vegetables, both for export and domestic markets, with the increasing participation of large-scale retailers.

Vegetables Grafting

Vegetable production under protected cultivation is increasingly based on the use of grafted plants. For this reason some data related to the dynamics of this innovative agronomic practice are reported (*Fig. 7*).

The use of grafting is mostly concentrated on a few vegetable crops belonging to the Solanaceae and Cucurbitaceae family. In particular, the main crops where grafting is used are: tomatoes, eggplants, melons, watermelons, cucumbers, and bell peppers. The increasing use of grafted plants addresses the need to control environmental stresses in a sustainable way, especially those arising from soil borne pathogens.

Figure 7 – Tomato grafted plants are widely used in protected cultivation.

The vegetable growing areas where grafted plants are mostly used are located in Sicily and Sardinia. The climate of these regions permits longer production cycles under greenhouse conditions, consequently it is necessary to have plants with a strong root apparatus that is able to sustain crop productivity over time. *Tab. 5* clearly shows the considerable amount of grafted plants currently used in Sicilian and Sardinian vegetable production. The use of grafted plants has also become very popular in other regions such as Lazio, Campania, and Veneto.

Species	N° of plants (million)	Greenhouse area (%)
Tomato	22	25
Watermelon	18	90
Eggplant	16	75
Melon	10	40
Total	**66**	

Table 5 – Grafting incidence in Sicilian and Sardinian horticultural production (Del Grosso and Morra, 2016).

Production of Flowers and Ornamental Plants

The commercial floricultural industry includes bedding plants, potted flowering and foliage plants, propagation material, and cut flowers. In Italy, floriculture crops are produced over an area of about 30,000 hectares, equally divided between floriculture (cut and potted flowers and foliage plants) and ornamental nurseries (MIPAAF, 2017) (*Fig. 8*). Floriculture, in its entirety, makes a significant economic contribution to the Italian horticultural sector, with a production value of about 2.5 billion of Euros. This sector has over 100 thousand employees and 27 thousand farmers. In addition to the commercial floricultural industry, the contribution of ornamental plants to urban green areas (*Fig. 9*) and their ecosystem services are also worth noting. The economic value of these benefits is very high and often underestimated. Elmqvist et al. (2015) showed that data from some studies supports the finding that the analyzed ecosystems provide between US$ 3,212 and 17,772 of benefits per ha, per year.

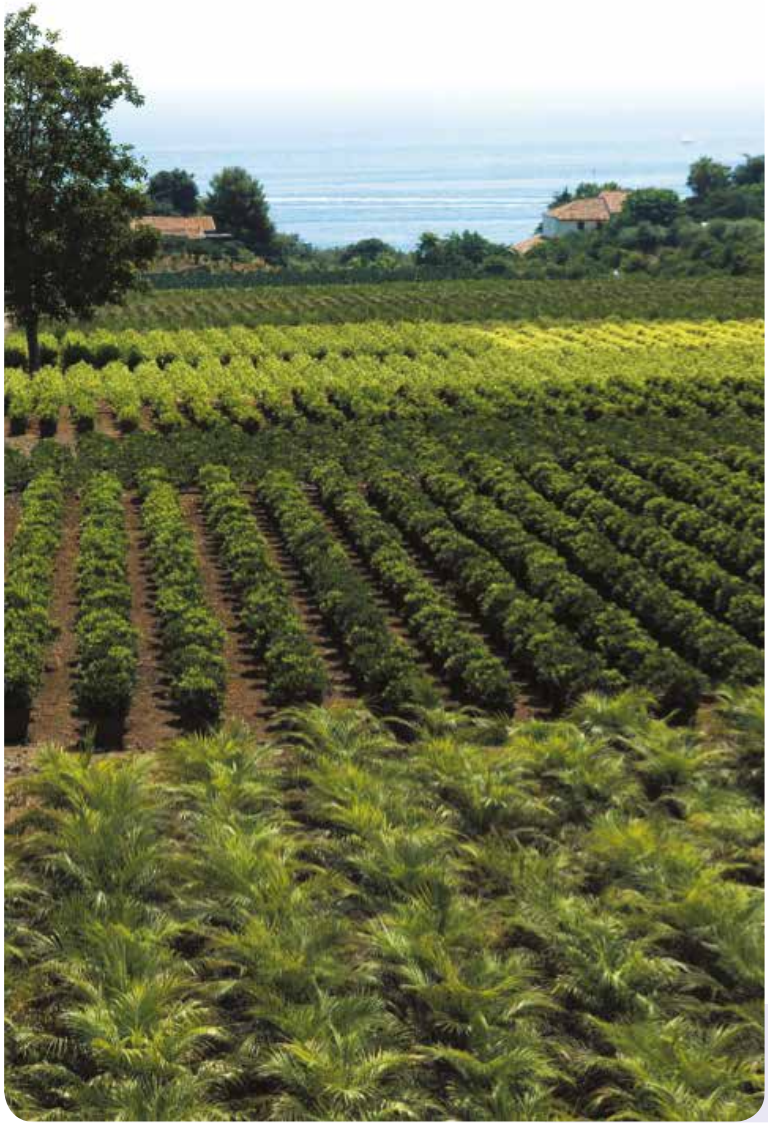


Figure 8 – Ornamental plant production in a nursery located in Sicily.

In the last few years, international trade of ornamental products has increased, motivated by developments in the consumption of ornamentals in different continents and countries. The competitiveness of some countries (e.g. the Netherlands) and developing countries has caused problems for traditional Italian floriculture, and in particular for cut flowers (*Fig. 10*). The Italian industry's problems are linked to the small size of the farms, which rarely exceed 1 hectare for flower growing and 2 hectares for nursery activity. The ornamental plant industry is characterized by its great diversity.

The later is considered the joy and the bane of floriculture (Dole and Wilkins, 1999). Over the past twenty years, new cut flowers and other ornamental products were introduced to the ornamental industry. The complex structure of the flower and nursery chain is represented by endless phases, relationships, choices and actions that involve numerous different people.

In particular, greenhouse floriculture involves the production of cut flowers (roses, carnations, orchids, gladioli, chrysanthemums, etc.), potted plants, bedding and balcony plants, and nursery plants (Rhododendrons, azaleas, chrysanthemums, begonias, geraniums, impatiens, etc.).

Although the greenhouse production of flowers and ornamental plants has significantly shrunk during the past few decades, it remains an important sector of the greenhouse industry in some specific geographic areas (e.g. Latina, Imperia, and Pistoia province).

High-tech and medium-tech greenhouses are typically used for producing flowers and ornamental crops. Advanced technologies such as soilless culture, automatic sowing/transplanting machines, movable benches and robots are often used in the largest farms for reducing labor and producing year-round high quality plants in an environmentally friendly way.

Figure 9 - Parco delle Erbe Danzanti at Paratico (BS), an interesting example of landscaping.

Figure 10 - Greenhouse cultivation of chrysanthemums.

Some farms producing flowers or ornamental plants are also involved in breeding and plant propagation. A few farms located on the Tyrrhenian coast of Central Italy (e.g. Civitavecchia) use geothermal sources for heating the air/soil within the greenhouse. Rigorous quality control procedures and full traceability during the whole production process are adopted to guarantee high quality flowers and ornamental plants for export and domestic markets.

Floriculture and ornamental plant nursery production are among the most specialized examples of intensive agriculture, with the large use of nonrenewable resources to maximize plant growth and reduce production time. For this reason, in the last few years increasing attention has been paid to sustainable management systems for floriculture and ornamental horticulture, encompassing the social, economic and environmental component of the region, with particular attention to some key environmental aspects (consumption of resources, use of soil, production of waste, etc.).

CHAPTER THREE

BIODIVERSITY AND GENETIC RESOURCES

P. Engel, M. A. Palombi, D. Neri, C. Fideghelli, F. Branca, C. Leonardi, V. Scariot

Introduction

After the first survey on fruit genetic resources present in Italy carried out by the National Research Council in the 1980's, the most important national project on Plant Genetic Resources (PGR) has been financially supported since 2004 by the Ministry of Agriculture, Food and Forestry Policies (MiPAAF). The project has been coordinated by CRA-Research Center for Fruit Cultivation in Rome, now CREA-OFA and includes 28 CREA[(1)] structures, the CNR[(2)]-Institute of Biosciences and Bio-resources and the NGO "Rete Semi Rurali".

One of the most important aims of the project has been the creation and regular updating of a database of all plant genetic resources conserved ex situ in Italy.

This database is available online, within the PlantA-Res portal (http://planta-res.entecra.it), in both Italian and English.

In 2008, the National Plan for Agricultural Biodiversity (PNBA) was approved by the MiPAAF with the aim to coordinate initiatives and relationships with national and international entities involved in the management of Genetic Resources for Food and Agriculture and to allow regional administrations to identify and take adequate steps to protect agricultural biodiversity.

View of the National Center of Fruit Germplasm in Rome (CRA-FRU)

According to the updated inventory in PlantA-Res, 24.516 accessions of horticultural GR are conserved ex situ in Italy, belonging to 74 genera and 446 botanical species (*Tab. 1*). 48 gene banks/collections have been assessed; however, the distribution of assessments in quite unequal among the 3 crop groups.

This is due to two reasons: i) so far, investigations have been more active concerning fruit collections, ii) the number of vegetable and ornamental gene banks/ collections is smaller.

The FAO International Treaty (IT) on PGR for food and agriculture was ratified by the Italian government in 2004; the respective Italian law entrusts the Regions and autonomous Provinces with the authority to achieve the objectives of the Treaty concerning the safeguarding and management of local plant varieties for food and agriculture.

(1) CRA: *Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria (Council for Agricultural Research and Economics)*
(2) CNR: *Consiglio Nazionale delle Ricerche*

group	no. of accessions	genera	no. of species	CRA institutions	other institutions(*)
fruits	19,665	37	179	9	25
vegetables	4,370	26	88	5	4
ornamentals	481	11	179	4	1
Total	**24,516**	**74**	**446**	**18**	**30**

Table 1 - Horticultural crops conserved ex situ in Italy.
(*) Other institutions comprise 14 Universities, 2 institutes of the National Research Council (CNR), 6 regional agricultural service stations, one technical school, and two private collections

Lemon terraces at Amalfi Coast (Southern Italy)

Winegrapes in Central Italy

The MiPAAF is responsible for international coordination, while the regional activities are dedicated to the recovery, characterization, conservation and valorization of PGRFA (Plant Genetic Resources for Food and Agriculture). Important financial support in this regard has been provided to the regions and autonomous Provinces through the Rural Development Programs of the European Union (RDP) 2000-2006, 2007-2013, as well as the recent one (2014-2021).

Region	Total	Fruits	Vegetables	Ornamentals
Abruzzo	81	44	37	-
Aosta Valley	114	114	-	-
Apulia	data not available			
Basilicata	212	211	-	1
Calabria	290	211	78	1
Campania	112	112	-	-
Emilia-Romagna	71	70	1	-
Friuli Venezia Giulia	27	9	18	-
Latium	183	143	40	-
Liguria	46	30	16	-
Lombardy	9	-	9	-
Marche	59	38	18	3
Molise	113	39	74	-
Piedmont	8	-	8	-
Sardinia	67	-	67	-
Sicily	251	251	-	-
Tuscany	104	57	47	-
Trentino South Tyrol	18	18	-	-
Umbria	367	281	86	-
Venetia	2	2	-	-
Total	**2,134**	**1,630**	**499**	**5**

Table 2 - Number of accessions of horticultural crops conserved on-farm in Italy, divided by regions and crop groups.

[3] PDO: *Protected Designation of Origin*
[4] PGI : *Protected Geographical Indication*

One of the consequences of the efforts dedicated to the valorization of local GR is the high number of Italian products marketed under the European PDO(3) and PGI(4) quality designations which, according to recent MiPAAF data, include 99 fruits crops (including olives and wine grapes) and 44 vegetables (March 2015).

No.	Fruits	no. of accessions	Vegetables	no. of accessions	Ornamentals	no. of accessions
1	almond	38	artichoke	8	*Choenomeles*	1
2	apple	406	asparagus	2	*Jasminum*	1
3	apricot	32	anise	1	*Rosa*	3
4	azarole	2	basil	9		
5	cactus pear	8	bean	214		
6	carob	6	beet	2		
7	*Citrus* spp.	13	broccoli	5		
8	cherry	116	cabbage	6		
9	chestnut	29	celery	3		
10	cornelian cherry	1	chickling vetch	23		
11	fig	84	chick-pea	26		
12	grape	144	cicory	5		
13	hazelnut	7	cowpea	11		
14	jujube	2	cucumber	4		
15	lemon	5	eggplant	5		
16	loquat	12	faba bean	5		
17	medlar	2	fennel	1		
18	mulberry	12	garlic	7		
19	olive	84	Italian squash	12		
20	orange	10	*Lagenaria*	1		
21	peach	68	leek	1		
22	pear	383	lentil	8		
23	persimmon	9	melon	17		
24	pistachio	5	onion	19		
25	pomegranate	17	pea	4		
26	plum (European)	104	pepper	13		
27	quince	10	potato	8		
28	service tree	5	pumpkin	12		
29	strawberry	5	radish	1		
30	strawberry tree	2	spinach	1		
31	walnut	9	thistle	1		
32			tomato	49		
33			turnip	10		
34			vetch	1		
35			water melon	4		
	Total	**1,63**		**499**		**5**

Table 3 - Horticultural accessions per crop conserved on farm in Italy.

Horticulture in Central Italy

Regional activities targeted at on farm conservation of plant genetic resources, carried out by "custodian farmers", appointed and paid by their respective regional administrations. According to recent data (2013), a total of 2,134 horticultural accessions are conserved on farm (*Tab. 2*), 1,630 of which are different fruit varieties, 499 are vegetables, and 5 are ornamentals; together, these represent more than 90% of all the plant accessions (2,262) conserved on farm.

As can be seen from Table 3, among the 31 fruits species, the most important ones are apple, pear, grape, cherry, fig, and olive; among the 35 vegetable species, bean comprises more than 40% of all the accessions, followed by tomato, chick-pea, chickling vetch, and onion.

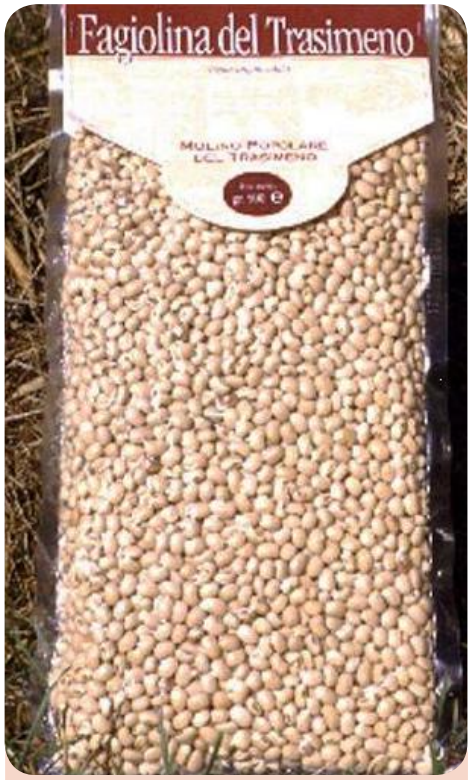
Mountain viticulture in the province of Trento (Northern Italy)

Cherry flowering at Vignola (Northern Italy)

Limonium spp., Sicily

Plurisecolar wild olive tree growing in the open landscape in Sardinia Island

Lens flowering at Castelluccio di Norcia (Central Italy)



Old bean variety of Trasimeno

Fruits

According to the updated inventory on PGR published in the PlantA-Res portal, the fruit accessions conserved ex situ in Italy belong to 54 different crops (temperate and subtropical zone crops, nuts, small fruits, citruses, grapes and olives) represented by 167 botanical species. They are classified as cultivars (32%), old varieties (47%), breeding material (6%), crop wild relatives (5%), and others (10%) (*Fig. 1*).

According to a survey carried on in 2003, 91% of all the accessions were, in different ways, utilized and 9% not utilized at all (*Fig. 2*). Purpose of utilization was mainly for research (45%); exchange among scientific institutions (25%) and breeding (23%) were also important. A minor utilization was material supply to private people (6%).

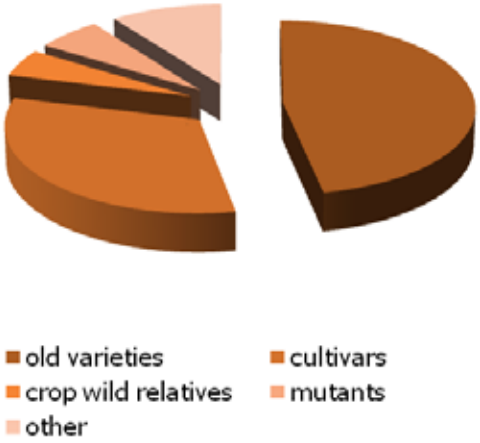


Figure 1: Typology of the fruit accessions present in Italy (PlantA-Res, 2015).

Figure 2: Utilization of the fruit accessions conserved by research institutions (Grassi et al., 2003).

Figure 3: Geographical origin of the autochthonous varieties (Engel and Fideghelli, 2012).

A recent survey of particular interest is based on the rich literature published during the last 40 years on the Italian autochthonous varieties of the main fruit crops: almonds, apples, apricots, sweet cherries, peaches and nectarines, pears and European plums. The term, "autochthonous varieties" describes old cultivars selected by growers, mainly from open pollinated seedlings and frequently of unknown origin.

4,373 accessions have been identified as autochthonous; among these, apples and pears are the most represented species, particularly in the North. They are followed by cherries, peaches and nectarines, almonds, apricots and European plums, which are more represented in the South (*Fig. 3*). Most of the cultivars were selected in the northern (35%) and in the southern regions (32%) of Italy, while 14% were originated in the central parts of the country (*Fig. 4*).

Special attention was paid to resistance/tolerance to biotic stresses (fungus and bacterial diseases, insects, virus, viroids, phytoplasma) and to the particular pomological traits of trees and fruits. *Tables 4 and 5* show the number of autochthonous varieties carrying positive traits, respectively resistance/tolerance to biotic stresses of pomological importance.

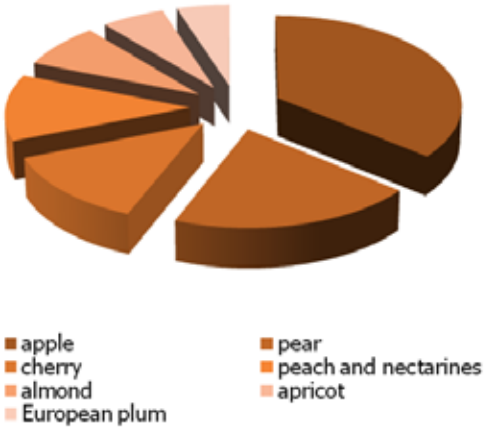


Figure 4: Composition of the Italian autochthonous cultivars (Engel, Fideghelli, 2012).

The red flesh oranges, typical of the Sicilian citriculture

Sweet cherry Kronio, selfertile, low chilling requirement: a variety selected in Sicily

Prugna d'Italia: European plum variety with low susceptibility to Monilinia laxa and Brachycaudus pruni

Crop	tolerance/resistance to				no. of varieties
	fungi	bacteria	virus, viroids, phytoplasma	insects	
almond	12	-	-	-	12
apple	189	-	4	15	208
apricot	22	1	28	-	51
cherry (sweet)	11	-	-	11	22
peach and nectarine	5	-	-	1	6
pear	45	2	-	58	105
plum (European)	5	-	-	15	20
Total	**289**	**3**	**32**	**100**	**424**

Table 4 - Italian autochthonous varieties and positive traits of horticultural and genetic importance: resistance/tolerance to biotic stress (Engel and Fideghelli, 2012, modified).

Cocomerina pear variety: a local red flesh variety

Durello apple variety: resistance to scab and tolerance to Podosphaera leucotricha and tree spur habit

Spina Carpi variety: pear highly resistant to Cacopsylla pyri

Crop	tree					fruit			Total
	spur habit	late bloming	self-fertility	low chilling	easy separation of the fruit from the stalk	red flesh	white flesh	resistance to int. breackdown	
almond	-	15	32	-	-	-	-	-	47
apple	67	-	-	-	-	1	-	-	68
apricot	-	6	-	3	-	-	2	-	11
cherry (sweet)	-	-	9	2	20	-	-	-	31
peach and nectarine	-	-	-	-	-	4	-	-	4
pear	-	-	-	-	-	4	-	4	8
Total	**67**	**21**	**41**	**5**	**20**	**9**	**2**	**4**	**169**

Table 5 - Italian autochthonous varieties and positive traits of pomological importance: tree and fruit traits (Engel and Fideghelli, 2013, modified).

Tuono variety: almond carrying the traits selfertility and late blooming

Filippo Ceo variety: almond carrying the traits resistance to Polystigma ochraceum and Fusicoccum amygdali

Tabacchiera peach variety, a flat peach grown since centuries on Volcano Etna slopes

The peach Persi del Vin: red flesh

Vegetables

In Europe, Italy is the lead country both for vegetable surface area (37 %) and for production (26 %) as well as being the first European country for vegetable seed production, providing about 14,000 t (FAOSTAT, 2012). Italian vegetable crops are largely grown in the southern Italian regions where two thirds of national surface area is located and which provides more than 50% of the national vegetable production (FAOSTAT, 2012). Thanks to favorable conditions, a significant number of vegetable crops are widespread in the country.

Peri-urban farm

In the previous century about 180 crops grown in Italy were described in the Trattato di Orticoltura (Viani, 1928), whereas about 200 crops were estimated to be grown in Europe (*Tab. 6*). In spite of the importance of the Italian vegetable industry at the European level, the number of cultivars registered in the thirty-third edition of the Common Catalogue of Varieties of Vegetables Species (31 EU countries), edited on December 2014, accounts for about 7 %, most of all composed of F1 hybrids. Although the great Italian vegetable diversity is not well exploited to qualify national seed production, the low number of varieties registered in the Common catalogue by our country offers a

Species	n° of accensions	Species	n° of accensions
Lycopersicon esculentum	942	Lactuca spp.	31
Capsicum annuum	441	*Brassica oleracea*	30
Pisum sativum	354	*Foeniculum* spp.	19
Allium cepa	274	*Raphanus* spp.	18
Phaseolus spp.	200	*Apium* spp.	17
Solanum melongena	158	*Beta* spp.	14
Phaseolus vulgaris	132	*Eruca vesicaria*	14
Brassica spp.	129	*Citrullus lanatus*	11
Solanum spp.	98	*Spinacia* spp.	8
Cucumis spp.	69	*Allium sativum*	5
Phaseolus coccineus	63	*Capsicum baccatum*	4
Cucurbita spp.	62	*Capsicum chinense*	4
Lactuca sativa	55	*Allium ampeloprasum*	3
Chicorium spp.	35	*Capsicum frutescens*	2
Abelmoschus esculentus	33	*Origanum* spp.	1
Solanum tuberosum	32		

Table 6 - Accessions of different vegetable species conserved at Italian Research Institutions (La Malfa and Bianco, 2006).

general idea about the wealth of vegetable landraces and its progressively loss since the late '90s. On the other hand, the large amount of types, landraces and crop wild relatives (CWRs) spread throughout our country are actively listed, conserved and exploited but only a few landraces are officially registered for commercialization. The great genetic diversity observed for vegetables in Italy is thus contributed to by several species, types and landraces, and is adapted to several pedoclimatic conditions present in our country as a result of the Italian peninsula's central position in the Mediterranean basin, which links North-Central Europe to the northern African coast. Of course, Italy's vegetable diversity is amplified by the different geographic origins of the species introduced into our country, which was colonized during the past by Phoenicians, Greeks, Carthaginians, Arabs, Normans, Spaniards French, Germans, etc.; the Italian maritime republics increased vegetable biodiversity during the Middle Ages by continuing to introduce new species and crops into our country through international trade. In addition, Italian vegetable diversity is amplified by the number of agrosystems where it is maintained, from the Alps to Sicily and from the Adriatic coast to Sardinia, as well as by the many natural habitats where a multitude of CWRs grow. In some cases, they characterized those distinguished traits of traditional Italian vegetables through progressive genetic fluxes. Some of these are qualitative traits that are tightly knit to Italian food and cuisine, and thus several traditional vegetables are actively requested in the local markets to use them for preparing traditional dishes, e.g. artichokes, broccoli, cauliflower, fennel, etc. If the genetic diversity, related to the species and crops, and the intraspecific diversity, related to the cultivars, is wide, then agro-ecological diversity is very interesting and is strictly related to the several growing systems and methods adopted in our country. The vegetable agrosystems can be divided into by kitchen gardens, intensive urban and peri-urban farms, and specialized farms with crops grown both in open fields and in greenhouses. Of course, up until now, vegetable diversity has been particularly

Beta vulgaris ssp. maritima: high resistance to saline and poor soils make it a precious component in breeding of the sugar beet

Pepper of Senise hanged for drying: a variety typical of Basilicata region

Wild Brassica growing in Sicily: B. rupestris

Wild Brassica growing in Sicily: B. incana

widespread in the first two categories, which are conducted by older growers who have only recently been flanked by members of the younger generations. This diversity is very endangered in kitchen gardens, as a consequence of its lack of economic targets and the increasing number of families living in urban areas and purchasing their plantlets from vegetable nurseries and shops that have replaced the traditional landraces with mass-produced material; in inland areas, this trend been limited and contrasted by older growers that have conserved and utilized traditional propagation materials. On the other hand, urban and peri-urban farms contain a large intraspecific diversity due to the numerous landraces selected over time by growers to satisfy the local community's requirements. From this perspective, vegetable genetic diversity is quite articulated and varied from region to region, showing several distinguished qualitative profiles in comparison to commercial cultivars grown in specialized agrosystems. On the contrary, in specialized agrosystems vegetable diversity is scarce and dominated by F1 hybrids that show a rapid turnover. Varietal groups that are characterized by qualitative traits appreciated by local consumers represent a rather particular contribution of Italian vegetable biodiversity. These include many types and landraces of coles (Brassica oleracea) such as violet and green curded cauliflower, sprouting broccoli, green and red kohlrabi, leafy kale, several squashes, such as bottle gourds (Lagenaria siceraria), winter and snake melons (Cucumis melo var. inodorus, C. melo var. flexuosus), long light-green zucchini (Cucurbita pepo) as well as solanaceous fruits, including small long shelf-life tomatoes and light violet and/or white eggplants. This diversity is also expressed through the use of different plant organs and structures, such as bulbs (garlic, onions), roots (turnips, parsnips, chicory, etc.), tubers (Jerusalem artichokes, potatoes, sweet potatoes, etc.), stems (kohlrabi, radishes, etc.) shoots (asparagus, hops, etc.), leaves (cabbage, cardoons, fennel, lettuce, Swiss chard, etc.), inflorescences (artichokes, broccoli, cauliflower, strawberries, etc.), flowers (zucchinis, borage, etc.), fruits (melons, pumpkins, tomatoes, etc.), and fresh seeds (fava beans, peas, etc.). The different organs of the plant utilized are often the result of grower selection for particular plant types characterized by hypertrophic growth or development, like what happened

for carrots and cole crops. Italy is an important hot spot for agrobiodiversity located in the Mediterranean center of origin and diversification of vegetable crops. Many wild species, often CWRs, are either gathered or occasionally cultivated and make up the rich vegetable genetic resources. Typical examples include Cynara cardunculus, a relative of the cultivated artichoke, whose small and thorny capitula are gathered and sometimes sold in local markets; the shoots and seeds of wild fennel (Foeniculum vulgare ssp. vulgare var. dulce) are gathered and used to prepare and flavor typical dishes; the bulbs of Leopoldia comosa are appreciated in the pickling industry; and the bitter spears of various species of Asparagus (A. acutifolius, A. albus, and A. stipularis) are often more appreciated than cultivated ones (A. officinalis). Other wild species occasionally cultivated are borage (Borago officinalis), whose boiled leaves are used in soups;

Sicilian cauliflowers

and caper (*Capparis rupestris*), whose flower buds, leaf buds, and young fruits are preserved in salt or oil and used as a condiment. The supply of these products is steadily diminishing due to changes in the traditional agro-economical and social contexts in which they were grown, particularly in peri-urban farms and home gardens. In these agrosystems, which are based on many species and landraces, there is the risk of genetic loss and drift caused by outcrossing with commercial cultivars. Peri-urban vegetable crops are also steadily declining as a result of competition from specialized intensive crop growers and the enlargement of towns, which increases land value within or near urban areas. In several Italian towns, the once important peri-urban vegetable farm belt is now reduced to just a few hectares. Despite this trend, there is currently renewed interest in seeking products that evoke the idea of genuine and typical food. Awareness is also growing that diversity loss needs to be faced and conservation activities must be implemented. Sometimes, ex situ conservation may be required while sometimes in situ or even on farm conservation strategies might be more appropriate.

Cynara cardunculus

Capparis rupestris

Finally, a general view of vegetable agrobiodiversity must include the several wild species that are occasionally collected in natural habitats and used as vegetables. This resource is future agriculture innovation's most precious resource. Over four-hundred wild species are reported to be still commonly collected and used on the peninsula, but many more were used in the past, such as Borago officinalis, Beta spp.,

Capparis spp., Cichorium intybus, Cynara cardunculus, Lactuca perennis , L. serriola, L. viminea, Brassica nigra, B. fruticulosa, Diplotaxis erucoides, D. muralis, D. tenuifolia, Eruca sativa, Nasturtium officinale, Raphanus raphanistrum, Sinapis alba, S. arvensis, Melissa officinalis, Mentha acquatica, M. longifolia, M. pulegium, Origanum spp., Rosmarinus officinalis, Thymus spp., Glycirriza glabra, Allium ampeloprasum, A. orsinum, A. vineale, Asparagus acutifolius, A. albus, Anethum graveolens, Apium nodiflorum, Daucus carota, Foeniculum vulgare and Valerianella carinata. For a few decades, Italian vegetable diversity has started to make important contributions to the small-scale agroindustry, which is often managed by family business executives, with profitable results thanks to the diversification of horticulture productive chains with traditional landraces and wild species. Of interest is the use of old long shelf tomato landraces for peeled and paste products, sweet and flavored onions for freeze-dried use, paste and grilled produce, rocket and several wild species for the ready-to-eat products, just to cite some of the many recent examples visible in several Italian regions. Traditional home-processed products are the foundation for innovating the Italian vegetable supply chain with economic results of interest for several rural communities. The antioxidant properties found in several traditional landraces and CWRs have recently been shown to meet important world market trends for nutraceutical produce actively requested by the consumers to alleviate human pathologies, above all chronic degenerative diseases. The case of the Brassica oleracea complex (n=9), is especially interesting; in Italy it comprises an ancient and large diversity with several landraces and CWRs widespread in many regions.

Cucurbita ficifolia

The use of Sicilian broccoli landraces and wild relative species in breeding has lead to new genotypes with high levels of glucosinolates of interest to consumers as a "super food". Of course, the added value of the nutraceutical traits must be supported mainly by organic vegetable production systems and methods. Thus, the exploitation of traditional landraces will thereby contribute to establishing new environmentally friendly agrosystems .

This great Italian vegetable diversity also plays an important role in modern society's requirements for rural tourist circuits or locally sourced markets and is an important starting point for innovation in world vegetable produce of quality for human health.

Lagenaria siceraria

Cucumis melo var. flexuosus

Asparagus albus

Ornamentals

Biodiversity in Italian Gardens

In Italy, there is no region that does not boast some famous garden. From those of the fourteenth and fifteenth century up to those built today with modern standards, Italy has a long and glorious garden history that retraces all architectures, styles and tastes. The variety of the Italian climate is reflected not only in their architecture but also in their botanical-floristic composition. Gardens from the dazzling green meadows of the Po Valley, Lombardy, Veneto, and Piedmont are dominated by species with cooler climate requirements such as azaleas, rhododendrons, camellias, maples, magnolias, etc., and dark green conifers that are reflected in hill and alpine lakes. The floras of the tropical and subtropical countries have largely contributed to enrich the gardens of Liguria with succulents (agave, aloe, cactus, prickly pear, etc.), palms, cycads, and Araucaria. The gardens of central Italy (Lazio and Tuscany) are dominated by cypress, maritime pines, olive trees, grapevines, oaks, and box. Finally those of inland and south central regions are rich in plants with exuberant vegetation, such as figs, prickly pears, palms, and citruses.

Isola Madre, an island of Lake Maggiore renowned for its botanical collections

Tropical and subtropical floras in Liguria

Botanical Collections

The interest of scholars, professionals, and plant lovers towards botany and the favorable climate of our regions have led to the creation of many botanical gardens and collections of ornamental plants such as roses, camellias, azaleas, rhododendrons, and cactaceae. The richnessof these collections have given or may give a contribution to the development of floriculture. Here, some noteworthy examples are reported.

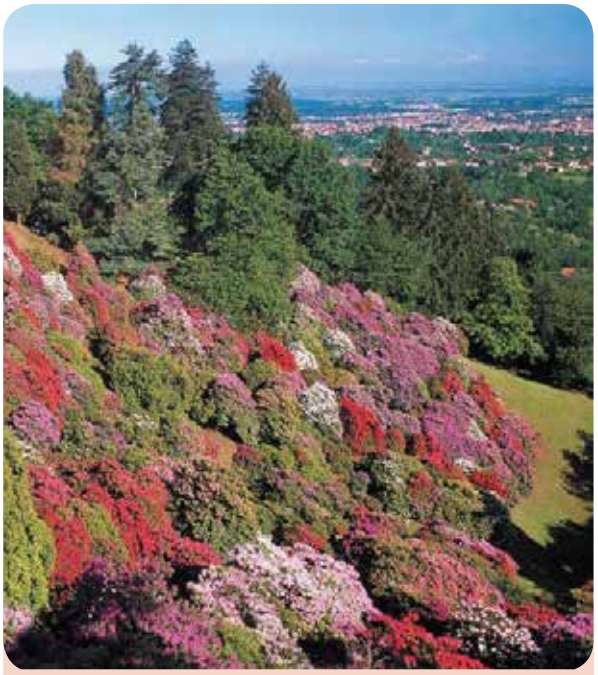
Roses

In an overview of botanical collections, the "Carla Fineschi Botanical Rose Garden" located in Cavriglia (Tuscany) definitely deserves to be mentioned. This rose garden came to life in 1967 thanks to Prof. Gianfranco Fineschi, a teacher at the faculty of medicine at the Cattolica University of Rome, and has become bigger as the years have gone by. This unique private collection houses over 6,000 species and hybrids from all over the world. Other notable rose gardens are present in Piedmont ("La Sorpresa"), Lombardy (Villa Reale in Monza), Liguria (Nervi) and Lazio (Rome).

Formal garden in central Italy

The garden of Donnafugata Castle in Sicily

Collections of garden roses are widespread throughout the country



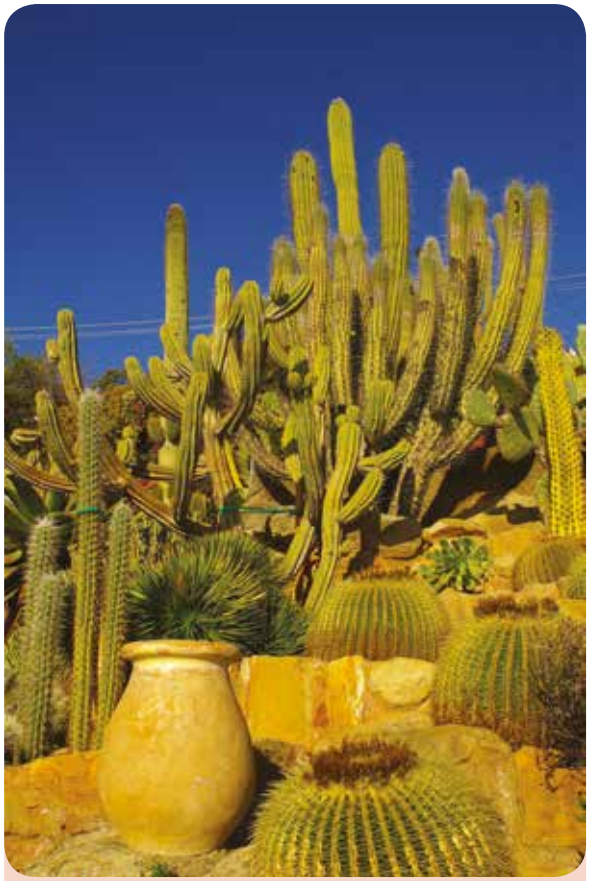
The Rhododendron valley in the Special Natural Reserve of the Burcina Park "F. Piacenza" (Pollone)

Azalea collections in Lake Maggiore district are present both in nurseries and parks

A rich collection of autumn and winter flowering camellias has been established by University of Torino in the park of Villa Maioni (Verbania)

Acidophilic Plants

The Lake Maggiore basin (Piedmont and Lombardy) is noteworthy for the collections of acidophilic species such as camellias, azaleas, and rhododendrons grown there. These plants arrived in the nineteenth century, originally from the far East, and arriving via northern Europe, Britain and Belgium thanks to adventurous plant hunters. Over the years, they have gradually acclimated to the environment and become closely linked with the territory. A unique rhododendron collection is located in the Special Natural Reserve of the "F. Piacenza" Burcina Park (Piedmont). The Rhododendron valley was built between 1892 and 1925 by Felice Piacenza. This valley covers about two hectares and holds one thousand evergreen rhododendron plants. A large variety of maples is also present in the area's gardens and nurseries.



The Exotic Garden Pallanca (Bordighera)

Maples with different shapes and colours characterize the production of Biella

Hellebore collections at the Regional Institute for Floriculture (Sanremo)

Cactaceae

One of the most complete and important exotic parks in Italy is the "Pallanca Exotic Garden". This private collection is the result of the passionate and patient work of the Pallanca family for four generations: in 1989, the institution opened to the public. It houses rare and interesting specimens of cacti from all over the world, which over the years have gradually acclimated to the environment of Liguria, some reaching exceptional sizes.

Daisy collections at the Regional Institute for Floriculture (Sanremo)

Floriculture

Floriculture is made up of a very broad and diverse group of herbaceous and woody plants grown in open fields and greenhouses to produce cut flowers and ornamental foliage, houseplants and flowering potted plants. In Italy, the cultivation of cut flowers on an industrial scale began in Liguria around 1856. The species grown in those years were essentially carnations, violets and roses. Gradually, the number of species has increased so much that over 60 species of cut flowers and foliage are now sold.

While the production of foliage remains the prerogative of Liguria, cut flower production is shifting more and more towards southern Italy, with the Campania region as a leader.

Collections are mainly preserved by historic private breeding companies.

The Liguria region continues to play a predominant role with a valuable germplasm of roses, carnations, ranunculus, alstroemeria, aromatic plants and cactaceae.

In parallel, some research institutes of the region house rich collections of daisy, hellebore, sage, rosemary, hibiscus, helichrysum, and passionflower.

In Northern Italy, a high degree of specialization has also been reached for poinsettias, geraniums, chrysanthemums, cyclamens and hydrangeas.

Moving further south, in Tuscany, we find rich collections of lilies, hydrangeas and limoniums.

Passiflora, Rosemary and Hibiscus collection at the CRA-FSO (Sanremo)

Sage, collection at the CRA-FSO (Sanremo)

Ornamental Nurseries

In the field of ornamental nurseries, the region of Tuscany plays a prominent role. Here, leading companies mainly located in the Pistoia area have rich collections of Mediterranean plants, citruses, evergreens, fruit trees, climbers, and topiary plants. "Hesperidarium" is a unique, international garden with over 200 varieties of ornamental citrus plants from all over the world. A real botanical garden where visitors can admire citrus plants from the 15th century as well as more recent rare exotic varieties originating from the southern hemisphere.

Local Flora

The Italian spontaneous flora, rich in genera and species, with multiple shapes and blooms, offers interesting possibilities for innovation in the field of floriculture. From the Alps to Sicily, Italy is characterized by very different environments and climates. The remarkable biodiversity found in different habitats of the peninsula is undoubtedly a botanical patrimony for breeding programs. As an example, in the framework of a project (Revflor) funded by the Italian Ministry of Agriculture, several universities and research institutes have collected and evaluated the ornamental potentialities of Arbutus unedo, Campanula, Centranthus, Cistus, Eryngium, Euphorbia, Centranthus, Cistus, Eryngium, Euphorbia, maritimum, Peucedanum, Salvia, and Verbascum.

Production of diverse Mediterranean plants in Tuscany

Spontaneous Cistus salvifolius and Cistus creticus in Sicily. A rich collection of Cistus spp. was established by the University of Catania

Limonium, Lilium and Hydrangea collections at the CRA-VIV (Pescia)

There are numerous regional initiatives regarding the protection of floricultural germplasm. Research studies for the recovery, characterization and exploitation of ornamental plant species of particular interest have addressed rhododendrons, camellias, azaleas, winter camellias, orchids, ranunculus, tulips, fronds, anemones, mimosas, oleanders, etc.

In 2014, a Focus Group on Ornamental Collections was born within the Italian Society for Horticultural Science (SOI). This group is working to monitor and survey the public and private Ornamental Collections present in Italy. The more salient information (number of taxa maintained, growing conditions, collection location, contacts, web presence, opening to the public) will be recorded in a database. The aim is to make a reality that is currently little known in our country more accessible.

CHAPTER FOUR

THE HORTICULTURAL LANDSCAPE

G. Barbera, D. Romano

Introduction

The Italian agricultural landscape, as shown by its diversity, is the result of the natural landscape's great variability as well as the ancient and complex human history that caused its continuous modification. A distinctive feature of the rural landscape is the presence of trees, sometimes considered as individuals ("monumental trees") and sometimes as groups (forests, orchards, hedges, gardens). In either case, they can be considered "the most expressive and most constructive main element" of the Italian landscape (Giacomini, 1975). The presence of fruit trees in the Italian landscape is cited by many authoritative Latin writers including: Columella, Pliny the Elder and Varro. In the Eighteenth century, foreign travelers who were amazed by the presence of such a variety of different fruit trees in the landscape also left many authoritative testimonials.

Today, the horticultural landscape exhibits both lights and shadows: "Over the last 60 years, the Italian agricultural landscape has followed two paths, that of abandonment and that of specialization. The former has led to degradation, landslides and fires … The latter has led to the prevalence of monocultures in the most fertile areas: simplified and homogeneous systems and landscapes, often composed of a single plant species, where … mixed cultivation was eliminated, dismissed as a useless leftover of the past in an agriculture designed to pursue exclusively economic ends" (Barbera, 2007).

Monumental Trees

An important element of the horticultural landscape is the presence of monumental trees. This category includes very old trees as well as especially large specimens, and trees with a particular shape and habitus. The very definition of "monumental" for trees proves that they belong to the world of culture as well as to that of forestry and agriculture. Several surveys have made it possible to identify many trees that characterize the rural landscape as well as the historic city parks where they are present.

Monumental olive tree in the Kolymbethra Garden, Agrigento. (courtesy of M. Bianca)

Ancient Roots

Landscapes change because they are the expression of the dynamic interaction between natural and cultural forces in the environment. Cultural landscapes are the result of this consecutive reorganization of the land in order to better adapt its use and spatial structure to changing societal demands (Antrop, 2005). Understanding the Italian landscape with its natural and historical peculiarities ... should help make land, as it were, "sacred": an immense site of rural archaeology, which cannot be modified or manipulated without a general consensus (Agnoletti, 2013).

A quintessential aspect of Italy's horticultural landscape is, in fact, its ancient roots. Changes have been determined by land reclamation projects carried out by Greek settlers, Etruscans, Romans and Arabs. Over the course of time, these same civilizations provided an incomparably vast contribution to agriculture, in the form of new plant species (i.e. Citrus),

Permanence of Roman centuriationes in the Italian rural landscape

cultivation techniques, planting and land delimitation methods, water collection and use. The Roman centuriationes are still part of the Italian rural landscape. During the Roman age a regular lot (square) of land of about 50 hectares was assigned to the centurions. Trees were also often present on the margins of this area, and elms were often used as supports for grape cultivation. This geometric layout has remained visible in the rural landscape of some Italian regions. Along the Tyrrhenian coast in Sicily the "Table of Alesa" was discovered, which describes the landscape present on the island during the Greek era. Trees define irregularly shaped areas, surrounded by stone walls that protect the crops against herbivores.

Reproduction of the Table of Alesa

It is interesting to note that this type of landscape is still present in southern Italy, in the areas less affected by intensive agriculture. Irrigation systems used by the Arabs are still present in Sicily in traditional citrus orchards.

The characteristic irrigation channel named "Saia", deriving from the ancient Arab irrigation systems

The Tree in the Landscape

A "jardino" (garden) of the island of Pantelleria devoted to cultivation of a single citrus tree

The jardini (gardens) of the island of Pantelleria (South of Sicily) are circular dry-stone buildings, reminiscent of the charm of the old orchard garden, a single tree protected by a fence. They represent the most expensive and laborious structure imaginable in any part of the world that permits tree cultivation, thanks to the creation of a particular microclimate. In fact, they create the ideal conditions in which the growth and the production of citrus becomes possible, in spite of the strong winds and the dry climate of this island that would otherwise make the cultivation of citrus plants very difficult. The industrial direction Italian fruit cultivation has taken, especially that of apples and pears, is especially evident in regions such as Trentino Alto Adige, where traditional fruit cultivation has completely disappeared. The intensification of fruit cultivation was achieved through a number of innovations, one of the most important being mechanization, which requires standardized tree spacing. Reducing the height of the trees to just 2-3 m means going from 500 to as many as 3,000 trees per hectare. The purpose of this is to reduce foliage expansion to facilitate pruning and gathering. Thus, the trees give a different character to the landscape, and the orchards tend to lose the aesthetic characteristics associated with a traditional identity.

Detail of a tree cultivated within the walls of the "jardino" in Pantelleria

Apple orchards in South Tyrol

The Olive's Role in the Landscape

The olive landscape in Tuscany

The olive tree characterizes the Mediterranean region. Even for this crop, different cultivation and pruning methods mark the different Italian regions. In particular, the mixed cultivation of olives was widespread in central Italy, but polycultural systems centered on olive orchards are also found in other Italian Regions. Currently in Italy, it is still possible to find many of the same olive-growing systems and landscapes that have been present in the country throughout the course of history. This diversity is evident both at the landscape level, and in the farming systems, which result from a combination of adaptation to the environment, agronomic approach, and the habitus of the trees. Further variability is determined by environmental conditions. When these are especially harsh - i.e. cold, extreme drought, strong winds – the trees are much smaller, as in the case of those of the island of Pantelleria, where they barely grow to a meter in height. The olive groves characterize the Italian countryside and represent an element of exceptional beauty and of great historical value: diseases caused by the bacterium Xylella fastidiosa in Puglia could lead to the disappearance of some of these landscapes.

Ancient olive tree in Puglia

Olive trees the island of Pantelleria

Ancient olive tree in the Sicilian countryside

The Grape Landscape

Vineyards are present in Italy from the Alps to Sicily. In the Mediterranean areas of Greek colonization, grapevines were traditionally cultivated as a small tree; while in the territories of ancient Etruscan influence, the grape vines were raised high up and eventually tied to trees. The vineyard landscape linked to Italy's endless wine heritage, in its diversity, is an agricultural landscape that gives greater "identity" to the Italian regions and for this reason must be preserved.

A way to explore Italy and get to know the grape landscapes is to follow "le strade del vino" (the wine trail), which is very widespread in various Italian regions. Along the way, it is possible to taste the local wines, encounter the people who make a living there, and experience these extraordinary landscapes.

Examples of different Italian landscapes strongly affected by the presence of vineyards

Citrus Orchards

The citrus landscape in Italy: "Conca d'oro" at Palermo (left) and "Costiera Amalfitana" (right)

Citruses only became economically important in the XIX century when more and more agricultural land began to be transformed and citrus production spread. Although the discovery of citric acid also contributed to citrus's extension, the most important element was the progressive transformation of the landscape due to the transformation of vineyards into citrus orchards and the creation of arable land though terraces ("muri a secco"). These citrus orchards, together with terracing, contributed to characterizing a region that has gained the importance of a "cultural landscape" because of these traits.

For quite some time, Citrus species have been important ornamental plants that have stimulated strongly botanical collections. Cosimo III of the Medici family in Florence put together the largest articulated collection of citruses, which includes the germplasm existing in Italy at the end of XVII century. Citruses were cultivated in large pots, which were an important element in historic gardens; lemon houses and orangeries were built to house the plants during the winter.

Collection of citrus plants at "Boboli" garden

Features of citrus plants in an ancient citrus grove

Terraces

Emilio Sereni (1961) identified verticality as an original aspect of the Italian agrarian landscape, compared to the horizontality that dominates other European landscaping characterized by extensive plains. Indeed, terraces and the various ways of growing crops on a hilly slope have given our agriculture a remarkably "vertical" physiognomy. From the Alps to Sicily, a continuous diversity of climates, rainfall regimes, morphologies, soil composition, and plant varieties have forced the various agrarian civilizations that settled the peninsula to express their space-modeling and settlement-planning cultures in a variety of forms.

Different typologies of terraces in the Italian rural landscape

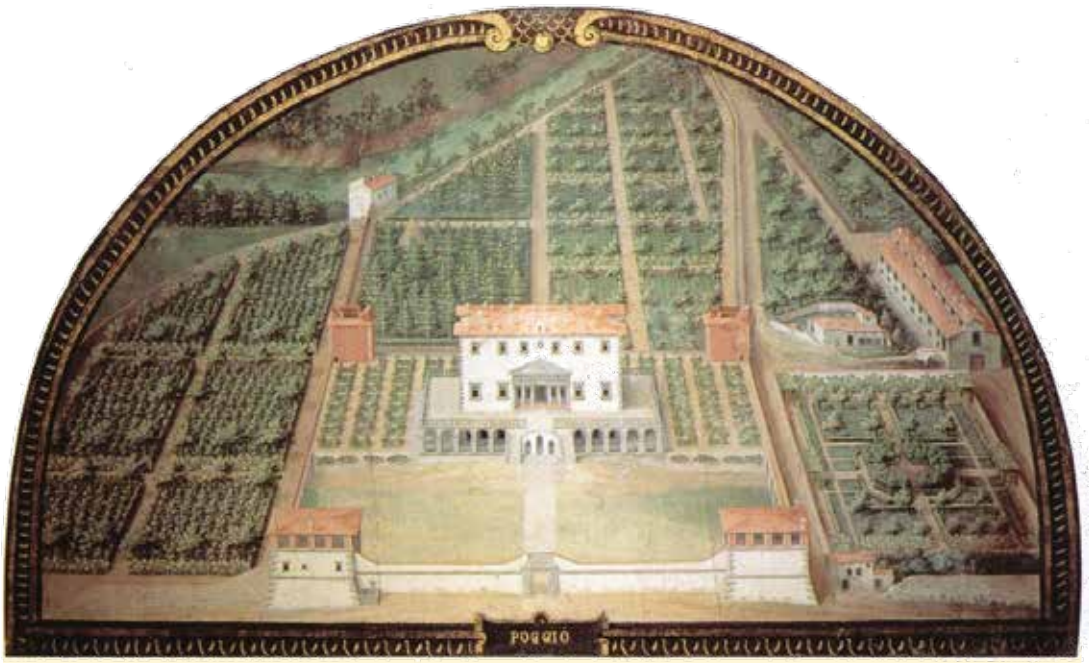
The European Landscape Convention

In 2000, the member States of the Council of Europe held the European Landscape Convention (ELC) in Florence, which introduced innovative features compared to earlier approaches to the landscape. In fact, the ELC provided a new definition of the landscape that applies to all landscapes and emphasizes how important diversity is as a landscape value. It also emphasized that the landscape is not the exclusive domain of academics, or scientific and technical specialists, but everybody's concern (Jones and Stenseke, 2011). It expresses awareness that the landscape contributes to the formation of local cultures and that it is a basic component of European natural and cultural heritage, contributing to human wellbeing as well as a consolidation of the European identity. It also notes that developments in agriculture, forestry, and changes in the international economy are in many cases accelerating the transformation of landscapes. Thus, the landscape became an important part of Communitarian policy.

Ornamental Gardens in the Rural Landscape

The Italian Renaissance garden was a new garden style that emerged in the late 15th century in villas in Rome and Florence, inspired by classical ideals of order and beauty, and designed for a pleasing view of the garden and landscape beyond, for contemplation, as well as for the enjoyment of the sights, sounds and smells of the garden itself. The villa commissioned by Lorenzo the Magnificent in Poggio a Caiano marks a fundamental change in the location of the villas, which are no longer tied to easy and convenient accessibility, but to the fertility of the area to be part of an organization with the purpose of agricultural production.

Even the same Palladian villas in Veneto (XVI century) fit into an often-agricultural landscape that hosts them well, without hardly any formal mediation. In the XVI century, fine-grained landscapes with the appearance of gardens became widespread in central Italy, thanks to the sharecropping system. Fields usually had a high number of trees and hedges, resulting in what is known as "mixed cultivation". Another element of connection between the garden and the countryside is given, especially in southern Italy, by the beauty of the rural landscape that becomes - as Sereni (1961) said – a garden itself.



Lunette by Giusto Utens of Poggio a Caiano, Florence (1599)

Ornamental Plants in the Italian Landscape

A characteristic feature of the Italian rural landscape is the presence of ornamental plants. It is possible to find many ornamental plants on a field's border, or flanking the entrances of agricultural properties or near rural housing. They are a detail that shows the care and attention with which agricultural activity was carried out, especially in the past. In the South, palm trees were typical, especially Phoenix dactylifera, symbolizing family unity. In Tuscany, cypress trees are widespread, and have become symbolic of the region's landscape. In Tuscany as well as in other regions, roses are placed at the head of vine rows to "protect" the vineyards; because roses are very sensitive to certain diseases (e.g. Powdery mildew), they signal the occurrence of environmental conditions that favor this disease before the vines are affected.

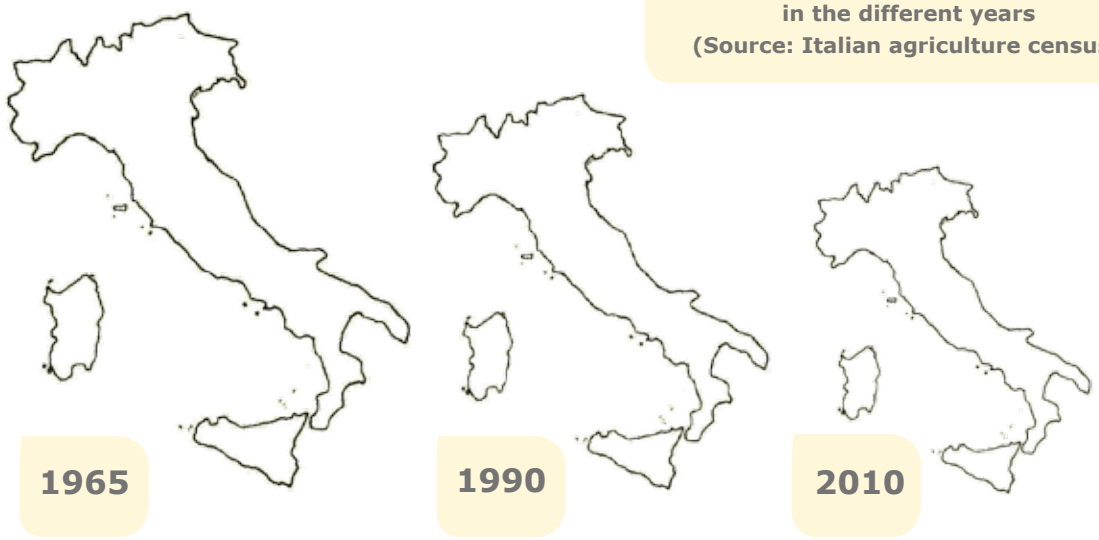
Cypress trees in the Tuscany landscape

The use of ornamental plants in the rural landscape

The Consumption of Agricultural Areas

The evolution of agricultural and forest land is a central theme in the Italian landscape. Today, millions of hectares of agricultural land have been lost to the expansion of forests and unproductive surfaces, a category that also includes urban areas. From the second postwar period on, the available data shows a sudden decrease of agricultural surface. In 1965, agricultural land covered about 20 million hectares; while in 2010, when the last agricultural census was conducted, farmland amounted to just 12.8 million hectares. That makes the abandonment rate about 160,000 hectares per year. Within agricultural surfaces, the most significant reduction was of arable land, followed by that of meadows and pastures.

The reduction of agricultural areas in the different years (Source: Italian agriculture census)



Protected Cultivation

Another significant phenomenon has been the internal transformation of agricultural surfaces, with a trend towards specialized cultivation. Wine, olive trees, vegetable farming and citrus production have all been impacted by these new trends, which have led to an intensification of production that is often incompatible with landscape quality.

For vegetable and flower crops, this intensification has led to an increase in protected cultivation, which has now almost reached an area of 40,000 hectares. Because protected crops are generally concentrated in a specific area, they significantly contribute to changes in the microclimate and hydrology of that area.

Tunnels in the South of Sicily

The Mixed-Cultivation Landscape

In suburban areas, horticultural crops are often distributed to form mixed cultivation, in which the single elements are represented by small areas of different colors and textures. The cultivation of different species in contiguous spaces, presence of scattered trees, terraces or particular cultivation methods all come together to create picturesque landscapes.

The cultivation of artichoke

Examples of the mixed-cultivation landscape in Veneto (above) and Sicily (below)

CHAPTER FIVE

THE JOURNEY TO YOU

G. Colelli, P. Tonutti

Fruits and vegetables remain viable after their detachment from the mother plant and undergo senescence processes and deterioration in the postharvest phase. Thus, the path from the field to the consumer's table is a constant struggle against the natural processes which lead to profound changes in composition and organoleptic characteristics, resulting in a decrease of the product's commercial value. Due to their high water content, fruits and vegetables are subject to numerous metabolic processes that accelerate under high temperature conditions. The most effective method to reduce the rate of these processes is to lower the temperature as soon as possible after harvest. Most products cultivated in temperate zones can be stored at temperatures around 0 / + 1 ° C (*Fig. 1*), while those of tropical or subtropical origin must be kept at 10/12 °C to avoid the appearance of cold damage (chilling injuries) and qualitative loss. In the case of the most important Italian fruit crops, proper refrigerated storage can extend shelf life from the harvest date by 2-4 weeks in apricots, cherries, and peaches, and up to 3-4 months in pears, kiwifruit and apples.

Figure 1 - Storage chambers set at 0-1°C for apples and chilling-insensitive fruits.

Fruits and vegetables are generally extremely sensitive to physical damage (wounds, bruises, etc.) and must therefore be handled with great care and attention throughout the post-harvest phase, including sorting and classification, transportation and marketing. In this regard, handling and conditioning are important factors, not only to maintain quality and prolong commercial life, but also to promote the product and to provide consumer guidance (trademark, place of production, variety name, product characteristics). In recent years, innovative packaging solutions with biodegradable materials and advanced technology have been developed.

For some products, postharvest quality can be further maintained through changes in the composition of the atmosphere surrounding the product, with both controlled and modified atmospheres (*Fig. 2*). The parameters that are modified generally relate to the concentration of oxygen (most frequently reduced to values lower than 5%, and in specific cases applying a dynamic control of its concentration throughout storage) and carbon dioxide (generally increased to values greater than 1.5%); the magnitude of these variations depends on the type of stored product.

Figure 2 – Storage chambers to study the effect of controlled and modified atmosphere on fruit quality.

These changes in atmospheric composition, in association with temperature reduction, are effective in slowing down the fruit's general metabolism (and therefore the deterioration rate), including the biosynthesis and action of ethylene, the gaseous plant hormone produced naturally by plant tissues which plays an important role in activating and accelerating ripening and senescence. The inhibition of the synthesis and/or action of ethylene is thus associated with an improved and prolonged storage life. Conversely, treatments with exogenous ethylene are used to accelerate the ripening of bananas, kiwifruit and tomatoes, and for the de-greening of citrus fruit.

In general, from a quality point of view, consumers look for freshness in a horticultural product, although other parameters such as size and shape, color and the absence of defects, including extrinsic parameters, can help driving the decision to purchase. Texture, taste and aroma, potential beneficial effects on health, and the absence of harmful organisms or compounds are the most important factors upon which the value of a product depends. It should be noted, however, that consumers are motivated to purchase fruits and vegetables in many and extremely variable ways. For example, while the importance of typical and local crops, and therefore of seasonality (also pertaining to sustainability), is recognized, some types of products (i.e. tomatoes) are now requested throughout the year. For this reason the different players along the production chain and post-harvest stage must respond rapidly and flexibly, adopting the most advanced available technologies especially regarding the evaluation and monitoring of the quality parameters that most affect the commercial products' life.

From this point of view, the application of reliable protocols and methods (including those non-destructive) to classify and determine organoleptic quality are essential to ensure consumer satisfaction, and to guarantee that the different actors and players along the production chain receive an economic return.

Italy is one of the leading countries in terms of fruit and vegetable production, traditional and innovative storage technology and the development of protocols and equipments for the qualitative assessment and selection of the harvested produce.

The Supply and the Cold Chain

Supply chain management entails the integration of organizations, people, technology, activities, information, and resources as needed as the product is successfully transferred from the manufacturer to the end customer.

The cold chain is highly important, given the perishability of fresh produce and the frequent need for long periods of transport and storage. A logistics system to respect the cold chain generally consists of pre-cooling systems and cold storage, refrigerated carriers, packaging, inventory management systems and information to allow traceability and monitoring of the product. The best way to maintain product quality after harvesting is to assure optimum temperature for preservation/transport to reduce losses due to deterioration and prevent contamination. For most crops grown in temperate climates, the product temperature should be maintained as close as possible to the freezing point to maximize the shelf-life; tropical and subtropical products should be stored above 10 °C to avoid cold damage. The optimal thermal conditions to conserve many types of fruits, vegetables, and cut flowers have been the subject of numerous studies over the last 50 years.

It is estimated that globally postharvest losses of fresh fruits and vegetables vary between 30 and 50%. In developing countries most of the losses occur between the field and distribution. This is mainly due to a lack of information about proper handling and storage of products as well as a lack of infrastructure, poor supply of electricity, an inadequate capacity of low temperature storage near farms, and inadequate transportation. In Italy, most losses occur in the final stages of the supply chain, particularly at the retail and consumer stage.

Best practices for the cold chain must start in the field, with particular attention to collection methods to avoid direct exposure of the product to sunlight and to adhere to proper pre-cooling. These precautions should then extend throughout the supply chain until the product arrives in the hands of the consumer.

Classifying Produce at a High Speed

The first fruit calibrators were developed from those used in other sectors: calibrators for eggs, for example, were adapted to divide fruits into categories based on their weight or size (*Fig. 3*). The advent and development of personal computers and appropriate software made very high computing capacity at a low cost and the real-time execution of increasingly complex classification algorithms possible. Thus, each fruit was monitored rapidly, based on weight or size, providing advantages in terms of precision and time saving. From then on, we faced constant progress in fruit and vegetable calibration and sorting technology.

Figure 3 – Apples entering the sorting line.

Modern systems are able to weigh and scan individual units within milliseconds, providing precise information for each fruit about weight, diameter, color, shape, density, sugar content (or other important compositional parameters), and the presence of internal and/or external defects. Using sophisticated technological tools, such as video cameras operating in the near infrared (NIR) spectrum, precision and accuracy are guaranteed. A single machine can employ up to 40 different lanes for sorting and classification with a potential working capacity of 240 bins per hour, which corresponds to more than one million carefully selected fruit for each hour of work.

Packaging

Effective packaging is essential for fruits and vegetables to protect the product during transport, avoid contamination, reduce dehydration, and prolong freshness, with well-designed and effective packaging acting as a guarantee of freshness, health and safety for consumers. Moreover, under optimal transport and packaging conditions, the deterioration rate of the produce is reduced. The search for technologies to maintain quality and extend the commercial life of produce has addressed researchers towards modified atmospheres for packaging a wide variety of products (*Fig.4*). Modified atmospheric packaging is a valuable aid for extending shelf life because it reduces respiratory activity, ethylene production, enzymatic reactions, and certain physiological changes, thus maintaining quality for a longer period of time. The appropriate gas compositions depend on the type of product; for example, low concentrations of O_2 and suitable CO_2 levels are is of utmost importance. Properly designed modified atmospheric packaging is always to be considered a complement and never as an alternative to refrigeration.

Figure 4 – Packaging of sliced and chopped fruits.

Innovative Packaging

The success of this technology has resulted in considerable evolution of packaging materials in relation to barrier properties, their potential benefits, and environmental impact. "Active packaging" materials are those that feature the classic barrier flanked by an active action aimed at restraining or releasing metabolic gas (including ethylene) and/or release antimicrobial compounds or physiological inhibitors in the head space, thus they contribute actively to the extension of the life of the product.

There is also "smart packaging" which refers to those materials with an ability to provide dynamic information about product quality along with the classic barrier function. It may be based on thermal history or the presence and concentration of some metabolites present in the head space. Packaging which can "tell" the degree of freshness or stage of maturation is the most common example.

Finally, commercially available polymers are fully biodegradable and compostable, and are often developed from renewable raw materials such as starch (Mater-Bi) and lactic acid produced by its fermentation (PLA). Such materials, having technological characteristics compatible with fruit and vegetable products, represent a valid solution to reducing the environmental impact of the modified atmosphere technology.

The "Fresh-Cut" Option

Fruits and vegetables can be prepared and packaged in such a way as to convenience the consumer. For example products can be cleaned, trimmed, washed, or cut into units or sub-units ready for use, while preserving the freshness and authenticity of the fresh product (*Fig. 5*). For more than 15 years, cut products have been an attractive option for Italian consumers and interest has grown steadily, with sales reaching a business volume in Italy of nearly a billion euro. These products include: leafy vegetables (lettuce, radicchio) or whole leaves, also known as baby leaves (rocket, spinach, lettuce), root vegetables (carrots), tubers (potatoes) or bulbs (onions), variously mature (tomatoes) or immature (zucchini, cucumbers) fruiting vegetables, stems or leaf stalks (asparagus, celery, fennel), flower buds (artichokes), inflorescences (broccoli and cauliflower) and flowers (squash blossoms), variously cut ripe fruit (melon, apple, pineapple).

Figure 5 – Ready to eat leafy vegetables packed in a plastic bag.

Most of the turnover in past years in Italy regards leafy salads and cut baby leaves.

In recent years, however, the sales of ready-to-cook soups, including various vegetables, and cut fruits markedly increased.

The commercial success of these products is due to several factors: the considerable service that is favored by a rising category of consumers who do not have time for meal preparation, and the advantage of ready to use products which involve no waste since the product is 100% consumable. These products are of high quality in terms of outward appearance, organoleptic and nutritional characteristics.

Greater handling, with respect to the starting product, generally corresponds to a greater tendency to deteriorate, requiring additional technologies aimed at obtaining a shelf-life compatible with commercial distribution (mainly packaging in a modified atmosphere), and strict control of the cold chain.

Italy ranks among the top countries for these types of manufacturing plants worldwide.

Traceability

The concept of traceability and the technological applications that make it possible to follow the product through its entire post-harvest phase are now an integral part of fruit and vegetable production. This approach ensures proper management of the various phases and calls attention to the presence of abnormal conditions that can alter a product. In addition to the application of advanced bar codes, new solutions include the use of RFID (radio frequency identification) able to identify the product, monitor in real time its geographical position and mileage, condition, surrounding environment (temperature, humidity), the extent of mechanical damage to which it has been subjected, and timing for the specific post-harvest phase at a given time. Some large supermarket chains already apply this technology extensively, not only for processed products, but also for fresh fruits and vegetables.

Product Safety

One of the problems consumers are particularly sensitive to is related to product safety, with regards both physical-chemical characteristics and the potential presence of organisms harmful to human health. Usually in fresh fruits and vegetables, these aspects are linked to factors that originate in the field and should therefore be strictly controlled (e.g. quality of irrigation water, use of synthetic products, protocols for the protection of crops). The development of technologies that are able to identify the presence of chemical residues with certainty and quickly determine the presence of specific pathogens harmful to humans in a product that has already been harvested and has entered the commercial sector is a challenge for researchers. Several solutions are now available on the market. The presence of pathogens and harmful insects is a serious problem for preservation, quality maintenance, and loss reduction. This is the case for products intended for export (for which some countries require quarantines) and for those intended for the domestic market for which the control and, if possible, the elimination of pathogenic organisms is a priority. Given that during post-harvest, with few exceptions, treatment with synthetic chemicals is not allowed, the application of technologies based on physical methods (i.e. short treatments with air, steam, or hot (45-55 °C) water, reducing oxygen content, or increasing carbon dioxide concentrations) is becoming more frequent. Also, the use of ionizing radiation has been studied in terms of its effectiveness in the control of pathogens, but there are still some doubts about the safety of this technique for human health. Experimentation concerning the effectiveness of controlling pathogens with natural substances (plant extracts, essential oils) is booming and it is conceivable that some of these treatments will be practical for the safe storage of certain fruits and vegetables in the near future.

High Isostatic Pressure (box)

Treatment using high isostatic pressure (HP) allows microbial inactivation even with relatively low temperatures. The application of HP to foods consists in packaging the product in a flexible material that can transmit pressure and loading it into a chamber that is resistant to high pressure that is filled with a suitable fluid that transmits pressure to the sample from all directions. When the chamber is closed, the pressure is increased to the desired value through a hydraulic system and maintained at this level for the necessary time. The system is then decompressed and the product discharged. Treatment with HP can extend shelf-life by stabilizing the product from a chemical and microbiological point of view without altering organoleptic and nutritional properties. The resistance of microorganisms to HP is quite variable and is influenced by the concentration of sugar and salt, water content, pH, and the presence of synergistic substances (CO_2); often it is necessary to combine it with a mild heat treatment to inactivate resistant forms. The action of HP on enzymes is different from that exerted by high temperatures: while the latter involves an irreversible alteration, application of a hydrostatic pressure of between 100 and 400 MPa induces a reversible inactivation. However, higher pressure levels can cause the denaturation of proteins with the permanent loss of enzyme function.

CHAPTER SIX

THE PEOPLE

P. Inglese, S. Nicola

From field to fork, horticultural products require many skills

A growing world population and the increase in wealth by many will increase the demand for horticultural produce to unprecedented levels. To meet this demand, modern horticultural production is critically dependent on knowledge. It needs technically competent, skilled people in all parts of the industry who can respond quickly to market opportunities and the vagaries of production.

- The horticultural system in Italy involves 465,000 farms, with an average surface area of 2.15 ha.
- The role of small family-scale based horticulture is very large, covering 32,000 ha and involving 390,000 farmers.
- There are 1,313,612 single farms dedicated to horticulture, 907,197 to olive oil and table olive production, and 388,881 dedicated to grapevine production.
- Fruit and table grapes represent 44% of the global Italian production and olive trees are cultivated on over 1,110,000 ha.

Grapevine production in Langhe Valley (Piedmont) (left) and table grape in Bari province (Apulia) (right)

- More than 60% of horticultural produce is sold in large retail and discount chains, while street vendors still account for almost 20% of the market and specialized greengrocer shops hold 17% of the market. Vegetables account for 53% of the fresh fruit and vegetables in the consumer's shopping basket; while fresh fruit, including tropical fruit (pineapple, bananas, mangos, avocados, papayas, lychees =5%) account for 47%.
- The total growing area dedicated to horticultural crops is more than 3 M ha, with the leading crop being olive trees with more than 1 M ha, which is the second agricultural crop in general, being durum wheat the first; the second horticultural crop is grapes, cultivated on more than 700,000 ha.
- Vegetables, including legumes and tuber crops, cover about 500,000 ha, with more than 37,000 ha in permanent greenhouses. The leading crop cultivated in the country is the processing tomato, grown on 70,000 ha on average per year.
- Ornamental plants and flowers cover roughly 12,000 ha, of which more than 5,000 ha are under protected cultivation.

(From left to right and top to bottom). Produce display in a supermarket, in a street market, in a greengrocer shop, in a farmer market

- The nursery sector of all horticultural species covers more than 25,500 ha, with most importantly about 16,000 ha being ornamental plants, 3,500 ha being fruit plants, and 3,000 ha being vegetable transplants.

Farm in Bergamo Province producing baby leaf vegetables for the fresh-cut industry

Tomato for processing: tomatoes at maturity (left) and harvest (right)

- Italy produces 26.6 M t of fruit and vegetables, including tuber crops. More than 21 M t are fruit, 15.6 are vegetables, of which 1.6 are tuber crops. 1.5 M t of vegetables is produced annually under protected cultivation, of which the leading crop is tomato, yielding 480,000 t per year.

Horticulture requires many skills at all levels to ensure success

Successful horticulture production requires specialist knowledge in many disciplines. In the last few decades, the expertise of farmers has moved very fast to include aspects such as management, finance, logistics, sales and marketing, which were almost unknown to older farmers. On the other hand, nanotechnologies, ICT, computer skills, and renewable energy are new essential skills for technical transfer specialists as well as aspects related to produce quality, nutraceutical and nutritional value.

Horticulture production requires special knowledge in many disciplines:

- seed production and nursery management
- crop management, including tree training and pruning
- plant physiology
- plant pathology and disease control
- entomology and pest control
- harvest management, including mechanical harvest options
- plant breeding
- soil and fertilizer management
- irrigation management
- weed control
- computing and software applications
- postharvest management, including quality
- project management
- budgeting and financial management assurance and product quality assessment
- information technology, including product traceability
- engineering, including specialized knowledge applicable to harvesting, storage and transport

Horticulture supply chain requires special skills:

- packaging technology
- sorting technology
- market research
- processing technologies
- shipping knowledge
- specialized promotion and marketing knowledge
- storage technologies (cool and controlled atmosphere)
- supply chain logistics
- sales and marketing

In many cases, one single operator should or must have most of those expertises, making horticulture one of the most difficult and knowledgeable fields of the whole agricultural sector. The skills required along the chain from farm to fork are so many and so specialized that they require continuous education and information acquisition.

Entrants to the knowledge world of horticulture can seek careers in many areas

On average, horticulture provides twice the amount of employment per hectare of production as cereal crop production. Horticultural crop production is an enriching and diverse job. It is estimated that the horticultural sector accounts for 60% (220,000) of the 366,330 employed people in agriculture, 22,695 are employed in the fruit processing industry, 8,994 in the oil production sector and 15,300 in the vineries (Sources: ISTAT, 2010, VI Censimento Generale dell'Agricoltura; IX Censimento Generale dell'Industria e dei Servizi, 2012; Annuario Statistico Italiano, 2014).

A few examples are:

- Information/technical transfer specialists
- Marketing and sales personnel
- Specialist engineers
- IT specialists
- Trade negotiators
- International marketing and promotion experts
- Financial management and investment professionals
- Scientists:
  - plant physiologists
  - environmental scientists
  - soil scientists
  - molecular biologists
  - sensory scientists
  - nanotechnologists
- crop management specialists
- postharvest specialists
- pest and disease specialists
- plant breeders

Training

Horticulture is taught at different educational levels in Italy. This includes special programs within technical institutes at the high school level (Istituto Tecnico Agrario), and degree programs from the undergraduate to doctoral level at universities. Horticultural science is primarily taught at universities. In Italian universities, professors in horticulture are grouped into two main areas of expertise, either in pomology or in olericulture and floriculture. Both areas include ornamental horticulture. In accordance with the Ministry of Education, the two groups are defined under scientific sectors, AGR/03 for the former and AGR/04 for the latter, although they often belong to the same departments and share the same Scientific Society (Italian Society for Horticultural Science, SOI). In the pomology sector, a prominent role is held in Italy by viticulture, citriculture and oliviculture, often with a high specialization in postharvest handling and processing. Specific major individual crops such as kiwi fruits, peaches and apples, among others, are highly studied throughout the universities, with great emphasis on economic aspects, even though minor crops are also studied. In olericulture and floriculture, a great role is played by tomato crops, with a high impact on both the fresh market and the processing industry. Outdoor and indoor plants are important for both food and leisure and receive particular attention from Italian professors, including the soilless culture sciences. Medicinal and aromatic plants are also part of this field of study. Urban horticulture, landscape and historical parks and gardens are part of both areas of expertise.

In 2015, there were 132 tenured professors (54 assistant professors, 41 associate professors and 37 full professors) and 13 non-tenured assistant professors working in fruit crop science. In olericulture and floriculture, there were 45 tenured professors (22 assistant professors, 15 associate professors and 8 full professors) and 2 non-tenured assistant professors.

Professors in horticultural science are distributed throughout 27 Italian universities, even though there are some universities without professors in vegetable crops and ornamental horticulture sciences (Università Politecnica delle Marche, Libera Università di Bolzano-Bozen, Università del Molise, Università di Modena e Reggio Emilia, Università di Parma, Università di Perugia, Università di Reggio Calabria, Università di Teramo, Università di Verona).

The Universities of Palermo, Florence and Bologna have the largest horticultural academic communities. The University of Palermo prevails with the most representatives in pomology (14), and together with Catania, Naples and Turin, also has the largest community in olericulture and ornamental horticulture. Most of the universities offer university degrees at both undergraduate (called "Laurea di I livello") and graduate levels (called "Laurea Magistrale"). The main course in pomology is "Arboricoltura Generale", which teaches basic plant physiology and orchard management fundamentals, while other courses are mostly specific (e.g. Citriculture, Viticulture, Oliviculture, Fruticulture, Postharvest physiology and handling, Fruit Quality management, Plant propagation and Nursery management). For the olericulture and floriculture sector, courses include inter alia Vegetable growing and management, Floriculture, Greenhouse horticulture and floriculture, and Ornamental production and management. In addition, there are a few graduate courses in Landscape management that are offered by professors according to their scientific sector, which either regard woody or herbaceous species.

In Italy, it is possible to study in several universities and obtain a joint degree. Specific examples are joint programs for MSc. The University of Bologna and the Free University Bozen-Bolzano offer a joint International Master in Horticultural Science (IMAHS), entirely taught in English, with the opportunity for the graduate students to also obtain a multiple degree after spending one or two semesters in one of the Universities that are part of the network established by the programs in Germany, Austria, or Hungary.

The 5 Universities of Torino, Milano, Palermo, Foggia and Sassari offer a joint MSc in Viticultural and Enological Sciences. The MSc is taught in Italian, although a major in table grapes is taught in English at the universities of Foggia and Palermo. Students can study at the different partner universities. Students seeking a double degree can spend the second year of study abroad in one of the EU Partner Universities participating in the European Master in Viticulture and Enology. The Universities of Genova, Torino and Milano and the Technical University of Torino offer a joint graduate degree in Landscaping and Green area design for Landscape Architects; it is a multidisciplinary program and the students can study at the different university partners according to their chosen major.

Specific PhD programs are offered in most of the 26 Italian universities in which horticultural science is present. Currently, the food production chain is facing many challenges, including dealing with the demand for sustainable agriculture, the impacts of climate change, local versus global horticulture, the increasing globalization of pests, diseases and outbreaks, and the need for a system approach. Horticulture is thus moving into an even more specialized field of expertize, requiring highly skilled and highly knowledgeable university graduates. The rapid escalation of food prices, and even food shortages, are an inevitable consequence of the short-sighted and short-term policies of governments and university administrations in developed countries who are allowing the demise of these degree programs. While we progress towards achieving the internationally established Millennium Development Goal, much work remains to be done. Horticulture can provide not only food but is about sustaining lives, livelihoods, landscapes and wellbeing.

Viable communities need horticulture's employment opportunities

The horticultural industries within the countries of the developing world need to achieve the level of sophisticated production that guarantees food safety and quality standards, as well as scalable economies for viable export opportunities.

The horticultural Industry in Italy is quite sophisticated and offers a wide range of opportunities.

Women have always had a substantial role in horticultural systems at various levels, from field work, particularly at fruit harvest or fruit thinning, to fruit and vegetable sorting, packaging and food processing, and flower handling. Landscaping and gardening has seen a high involvement of women as well. More and more women now have executive roles in the fruit or vegetable industry and this is particularly true for the most advanced sectors such as the wine industry.

Although mechanization of several operations is increasing in all stages of the production system, horticultural systems still require a high degree of specialization that also require a higher degree of education.

Large differences occur throughout the country, in terms of crop production systems.

Postharvest handling and processing of fruit in Apulia (left) and vegetables in Lombardy (right, courtesy of Bonduelle Italia S.R.L.)

Changing times require advancements in education and research

We live in changing times with the increasing urbanization of populations, increases in living standards, growth in the power of multinational supermarkets, decreasing numbers of food producing farmers (but aggregation of land and operations), governments having fewer rural MPs to represent the farming sector (less political focus on farming), and a decline in agricultural services to farming communities over time (more user-pays cost-recovery). Additionally, postharvest food losses remain unacceptably high despite international efforts to achieve Millennium Development Goals. However, government and donor finances, especially in R&D and extension work, have been severely curtailed. Education and training in horticulture should produce graduates who will become advisors and trainers to ensure that existing and proven farming information is fully utilized. Many institutions and farmers' organizations are involved in training farmers with seminars, workshops and other techniques.

1st European Conference of Post-graduate Horticultural Scientists - ECPHS, held in Palermo

Some of the higher profile organizations are:

International:

- FAO [Food and Agriculture Organization of the United Nations]
- CIRDAP [Centre on Integrated Rural Development for Asia and Pacific, based in Sri Lanka]
- APO [Agricultural Productivity Organisation, based in Japan]
- World Vegetable Centre [AVRDC, based in Chinese Taipei and Tanzania]
- Australian Centre for International Agricultural Research [ACIAR]
- International Fund for Agricultural Development [IFAD, based in Rome]
- The Global Horticultural Initiative [GlobalHort]
- US Agency for International Development [USAID]
- European Union [EU] – multiple programs
- International Tropical and Subtropical Fruit Network [TFNET, based in Malaysia]
- USAID Horticulture Collaborative Research Support Program [HortCRSP, based at University of California, Davis]
- Commonwealth of Learning [COL, based in Vancouver] – specialised in distance education and training
- CIRAD -Centre de Coopération Internationale de Recherche Agronomique pour le devéloppement - specilised in sustainable development of tropical and Mediterranean regions

In Italy:

- Universities (Politecnica delle Marche, 'Aldo Moro' di Bari, Basilicata, Bologna, Bolzano, Catania, Firenze, Foggia, Milano, Milano-Cattolica, Modena e Reggio Emilia, Molise, Napoli, Padova, Palermo, Parma, Perugia, Pisa, Reggio Calabria S. S. Anna, Sassari, Teramo, Torino, Tuscia, Udine, Verona).
- Accademia Nazionale di Agricoltura, Bologna.
- Accademia dei Georgofili, Firenze.
- Accademia di Agricoltura di Torino.
- Accademia Italiana della Vite e del Vino, Conegliano.
- Accademia Nazionale dell'Olivo e dell'Olio, Spoleto.
- Italian Society for Horticultural Science (SOI).
- CSO, Ferrara.
- Istituto San Michele All'Adige, Trento.
- Centro di Sperimentazione Agraria e Forestale, Laimburg.
- Agrion, Regione Piemonte.
- Ministry of Agriculture Institutes: CREA (Roma, CRA-FRU; Acireale CT, CRA-ACM; Pontecagnano Faiano SA, CRA-ORT; Milan, CRA-SCS; Palermo, CRA-SFM; Pescia PT, CRA-VIV; Sanremo IM, CRA-FSO; Caserta, CRA-FRC; Forlì CRA-FRF; Monsampolo del Tronto AP, CRA-ORA; Montanaso Lombardo LO, CRA-ORL).

CHAPTER SEVEN

HEALTH AND WELLBEING

G. Bounous, G. Gianquinto, G. Beccaro

Horticultural products are essential for human life and fundamental to the wellbeing of communities. Without horticultural products, human life would cease. The human body is designed to utilize the energy stored in plants and nutrients that are not available from any other source. Good health stems from wellbeing and horticulture contributes to wellbeing in a number of ways, not all of them apparent at first glance.

Horticulture is all around us

They could be called segments or subsets of the horticulture industry. They are in reality the 'cradles of creation' where the wants and horticultural needs of communities are satisfied by horticulture and the ingenuity of its entrepreneurs and farmers. These cradles of creation range from large turf farms to gardening centers and from plant and landscape growers to botanic gardens. They include small holdings next to cities, major large-scale vegetable and fruit farms and orchards, hydroponic growers of tomatoes and flowers, and the sack gardens of high-density towns in poor communities.
Many people take the benefits of amenity and ornamental horticulture for granted, but the benefits can be seen in office blocks and holiday resorts, zoos, urban buildings and offices. In every part of the world, horticulture's bounty is on display in the home gardens of those who understand and value the beautifying aspects of growing things. Even the rooftops in some cities have sprouted green gardens. The beautification of parks and streets, the green foliage on freeways and the ornamental plants that are the essence of urban landscapes are all part of horticulture's rewards. This huge diversity is collectively the mosaic of the world of horticulture.

Therapeutical Gardens in Italy

The use of gardening activities for therapeutic purposes with patients coping with physical and mental challenges has a long and consolidated tradition. The idea of considering the garden as a constituent space of the hospital goes back even further, and in antiquity the time spent by patients in the garden was viewed as an integral part of the therapy: for centuries it has been thought that the health and well-being of humans is positively influenced from being immersed in nature or within gardens. However, the design of therapeutic landscapes is

Examples of gardening activities for therapeutic purposes

an emerging sector in the field of planning, and there is a growing literature that shows the role of gardens in contributing to the fulfillment of therapeutic objectives. Gardening activities to deal with disadvantage and disabilities have also recently become increasingly popular in Italy as vocational treatments. The recent birth of the "Garden To Relive" (GTR) Neuro-rehabilitation Therapeutic Garden, in Venice at the San Camillo Hospital Foundation, has been an opportunity to promote successful synergies between the Hospital, the Research Centre in the Urban Environment for Agriculture and Biodiversity (RESCUE-AB) of the University of Bologna and the general public. Neurological patients may have different levels of motor and cognitive disability and the goal was to create a garden:

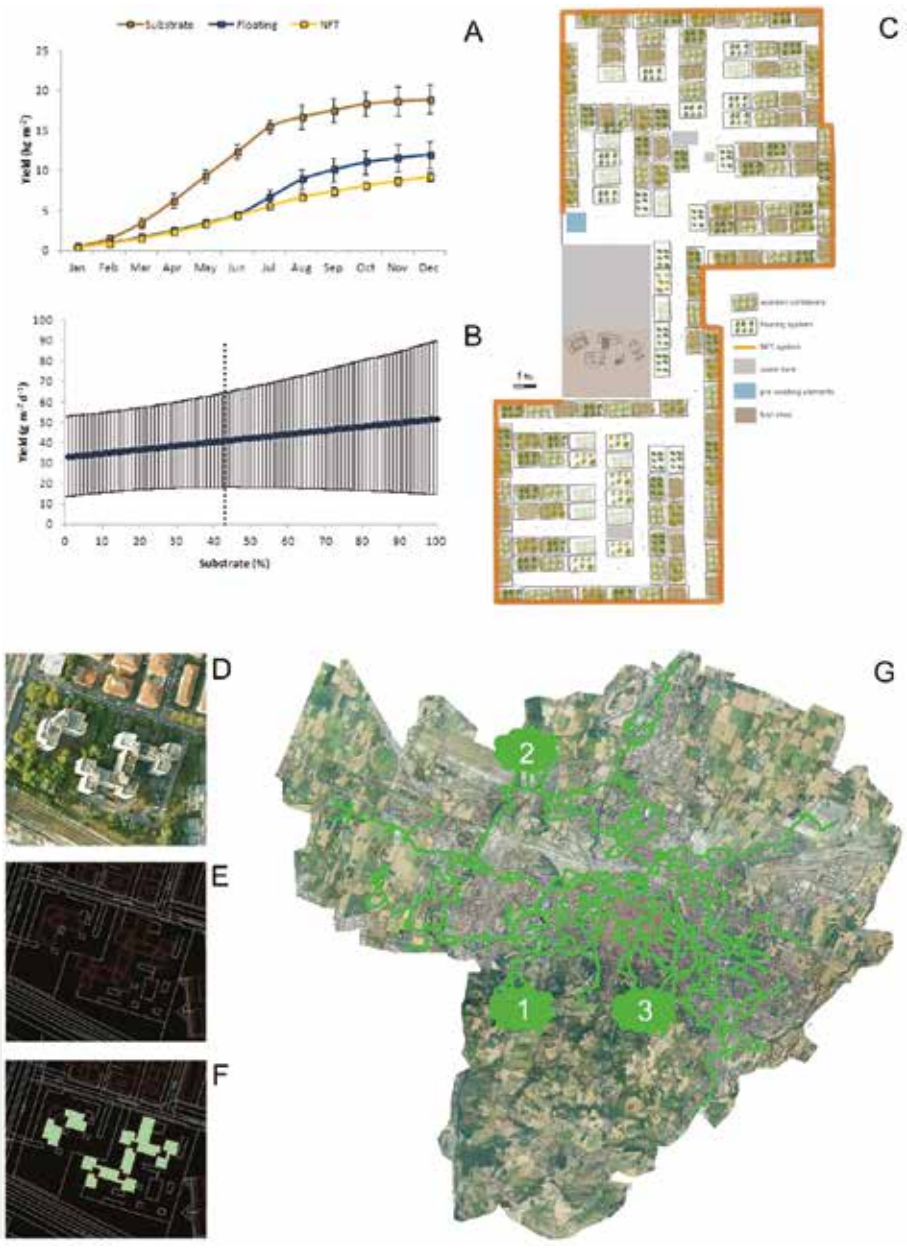
- accessible both via wheelchairs and safe for people walking with a support;
- furnished with working stations of appropriate height and design;
- with high biodiversity and organic crops;
- suitable for patients who need to recover from such ailments as post-stroke depression or to exploit their functionality before hospital discharge.

Moreover, the garden aimed to create a unique sensorial environment for patients with severe brain injuries who, in the absence of functional mobility, might benefit from colors, perfumes and tactile experiences.

Urban Horticulture and Food Production in Bologna (Italy) (box)

The contribution of urban farming to city food supply has been estimated in a number of cities across the world. However, its full recognition has been hindered by a lack of good quality, reliable data, given that comprehensive research has scarcely addressed this topic (Orsini et al., 2013). The city of Bologna (Italy) has always been at the forefront of urban agriculture in Italy. The city, whose medieval architecture still host a number of inner voids, such as parks and gardens that were formerly generated as "horti conclusi", was among the first ones that regulated urban allotment gardens in the 'Eighties. Today, the presence of allotment gardens is still one of the most relevant in Italy (more than 3,000 plots in the city area plus other 2,700 plots in the province). The commitment of the local municipality and University (where the first Italian Research Centre on Urban Horticulture and Biodiversity was recently established) has recently led to the implementation of the first rooftop farming municipal program in social housing buildings in Italy. These community gardens are promoted for their multifunctional role, which spans from food production, to a range of social and ecosystem services. Indeed, whenever locating food production within the urban environment, a concern for public safety arises. Due to the intense impact of human activities, the urban atmosphere may be loaded with several pollutants, among which heavy metal may represent a crucial risk factor. A recent study has made a comparative analysis of heavy metal surface deposition and tissue accumulation in vegetables simultaneously grown in rural and urban environments, according to their distance to main pollution sources and the growing system used (Vittori Antisari et al., in press). Results showed that in the city, crops near the road were polluted by heavy metals, with up to 160 and 210 mg Kg DW in lettuce and basil, respectively. However, whenever the garden was protected from the road by a tree alee or a distance of about 60 m, observed concentrations were similar to those seen in rural grown products. Furthermore, the adoption of soilless growing systems made it possible to further reduce heavy metal accumulation in plant tissue, by up to 71% for rosemary leaves. Further studies also addressed the quantification of food potential productivity: in the whole city, it was estimated that if the 82 ha of available rooftops would host simplified soilless gardens, a potential yield of 12,500 t / year could be obtained, covering more than three quarters of the city vegetable requirements (Orsini et al., 2014). The study was based on experimental trials on a pilot rooftop garden (over 200 m, hosting three simplified soilless systems and 8 vegetable crops and conducted over three years), and then extended to some of the

city's flat rooftops identified by aerial images and determined making use of computer-aided design (CAD) software. In the same case study, other potential benefits were estimated, including the creation of green corridors for biodiversity (up to 94 km of green corridors and a density of 0.67 km). Additional studies on the same pilot garden made it possible to identify the overall environmental and financial sustainability of the proposed growing systems (Sanyé-Mengual et al., unpublished data). According to the survey, the cultivation technique, crop yield and crop period strongly affected the environmental and economic outputs. For leafy vegetables, the most environmentally friendly options were the floating technique in summer crops (65-85% lower) and substrate production in winter (85-95% lower), whereas a simplified nutrient film technique was the least recommended option. In substrate production, eggplants and tomatoes were the fruit vegetables that showed the best environmental performances. For all types of crops, irrigation turned out to be the most environmentally impacting element, therein suggesting that rainwater harvesting systems or greywater regenerating units should be implemented. On the other hand, the utilization of re-usable elements and the relative use intensity of the garden improved the sustainability performance. The financial viability of the production of leafy vegetables was maximized in the floating system (0.67 € kg), whereas among tested fruit vegetables grown on substrate, the best performances were associated with eggplants (0.13 € / kg) and tomatoes (0.16 € / kg). Consistently, rooftop-farming production was observed to be an environmentally friendly option to further develop urban local food security.



Procedure for identification of optimal garden design (A, B, C), city available flat surface (D, E, F) and green corridors creation (G)

Quality-of-Life Interactions with Plants

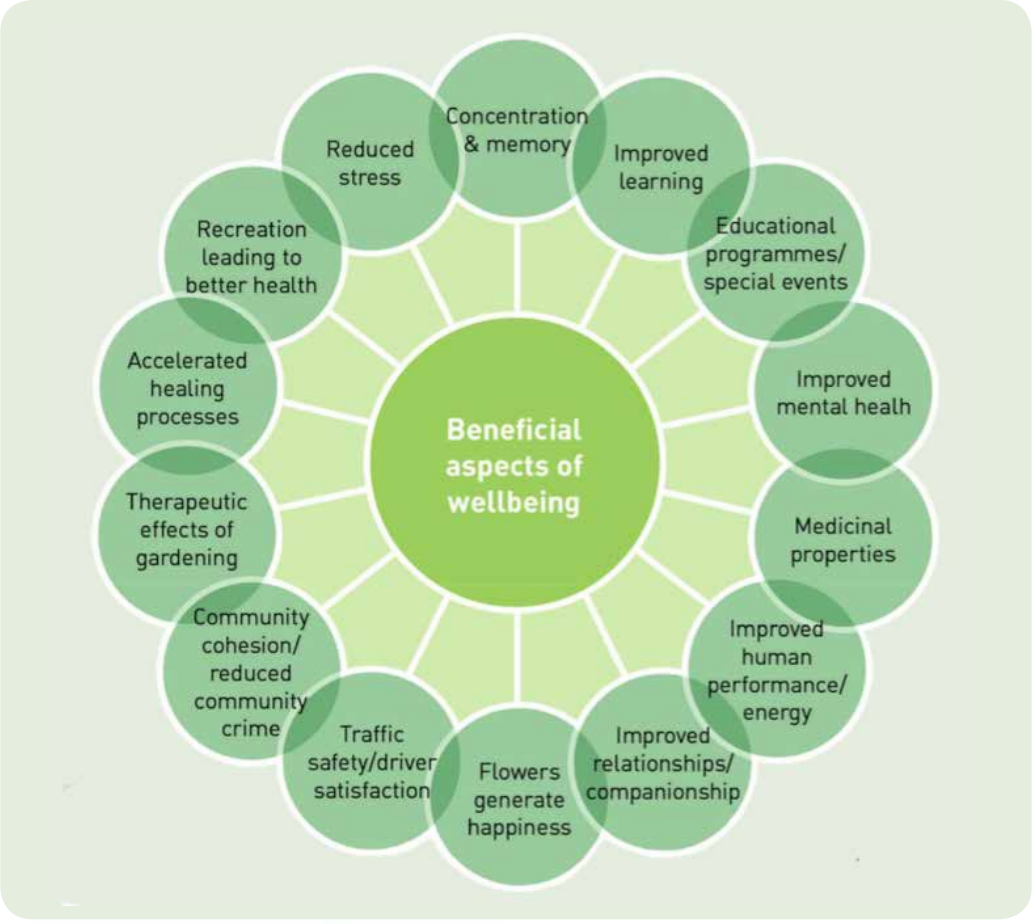
Scientists have developed an integrated model of quality of life and wellbeing, consisting of six major life domains:

- social wellbeing
- physical wellbeing
- psychological wellbeing
- cognitive wellbeing
- spiritual wellbeing
- environmental wellbeing.

The interactions between people and plants intersect each of the six quality-of-life domains.
Quality-of-life interactions with plants

Who benefits economically?

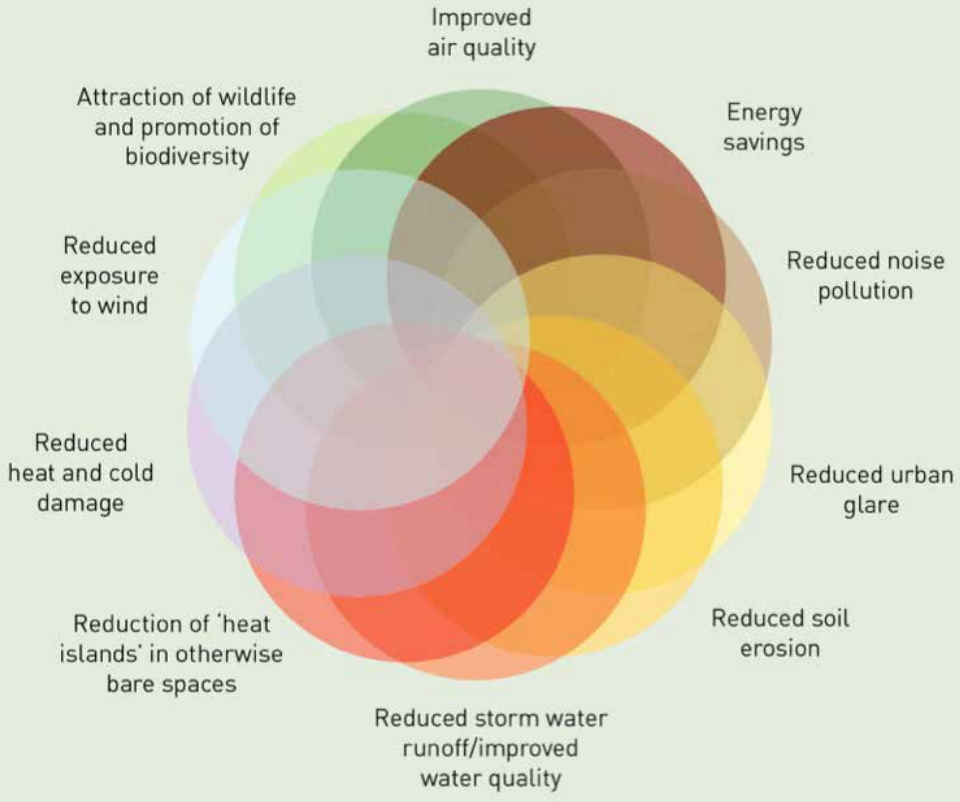
- Nursery plant and turf growers
- Horticultural service firms providing landscape and urban forestry
- Wholesale distribution firms including importers
- Services such as landscape design, installation, and maintenance
- Home improvement centres and mass merchandisers or other chain stores
- Brokers, transporters and retail operations
- Florists and independent garden centres.

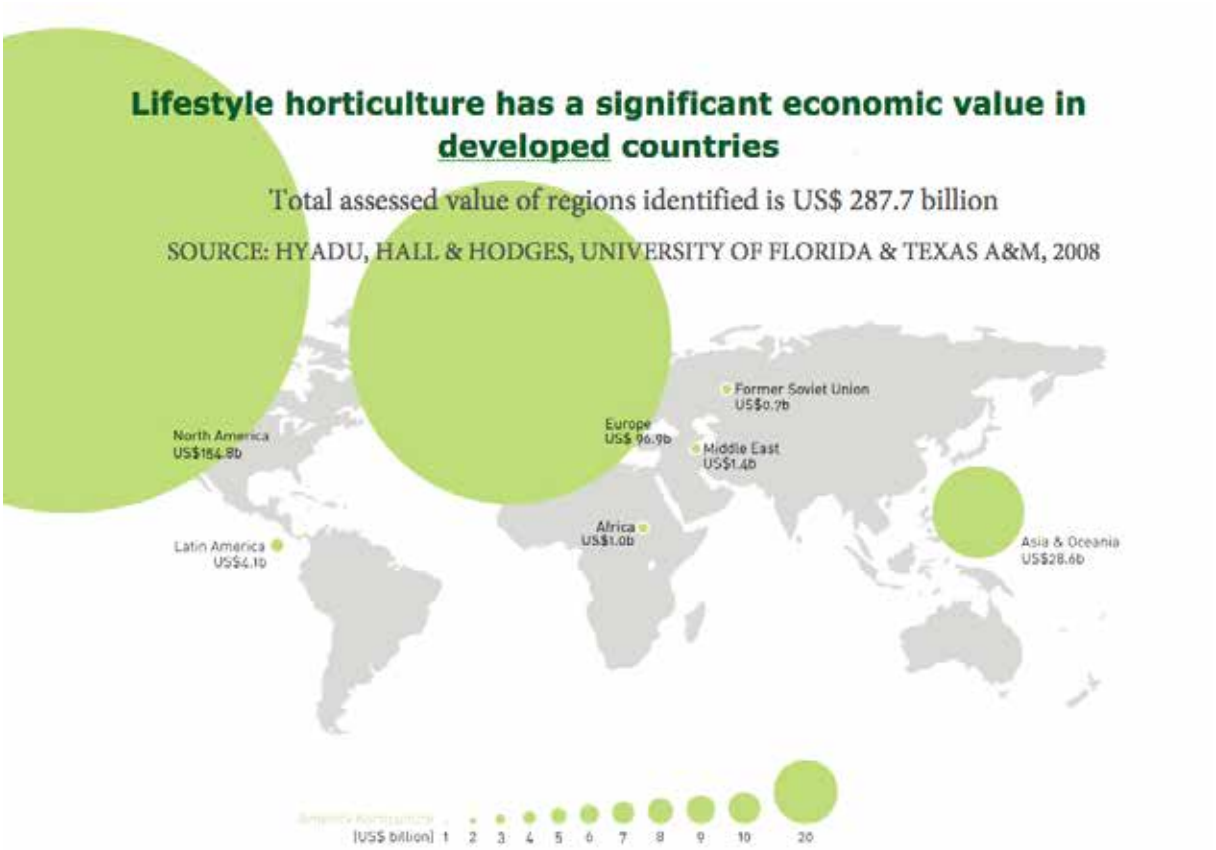


Berry fruits are among the most interesting smart foods and they have an ever growing market in Italy

Economic Benefits from Amenity Horticulture

Environmental Benefits from Amenity Horticulture





World amenity horticulture assessed at almost US$290 billion value

Parks and open spaces, the pot plants in your buildings and the turfed lawns of suburbia may look purely decorative but in reality they are lifestyle / amenity horticultural economic powerhouses and critical components of productive work environments and healthy communities. Using a benchmark study as the starting point, and adjusting the relative economic value of other regions of the world, a 2008 study estimated that the economic impact of amenity/lifestyle horticulture was close to US$ 290 billion. The study used reference points such as the value of a property besides or close to a park, versus a property that had no connection to a park or reserve. The world map above shows the makeup of the global estimate of the value of amenity horticulture.

Horticulture, health and wellbeing are strictly connected in the beautiful landscape of the Italian chestnut plantations

Horticulture for Improved Health

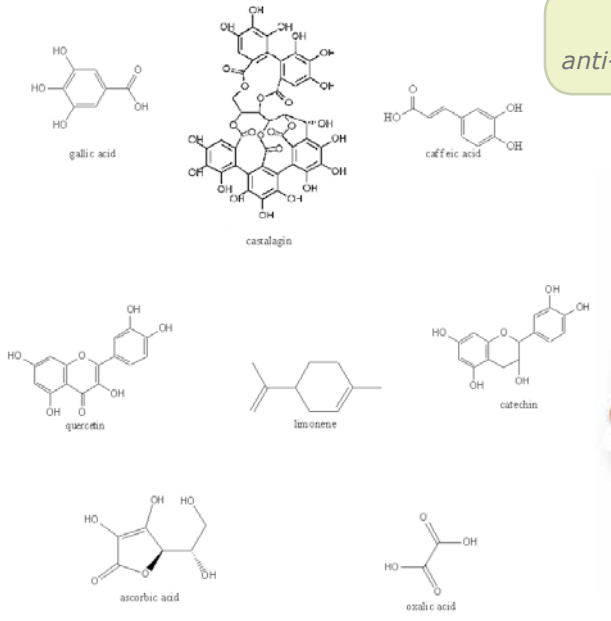
A 'big bang' is currently impacting the food, health food and pharmaceutical industries, among others. This 'big bang' derives from an explosion in research and publications providing scientific evidence to support hypotheses that phytochemicals in fruit and vegetables provide health benefits to the consumer. However, most people in the world lack adequate access to vegetables even though they are essential for good human health. Insufficient vegetable and fruit consumption (diets deficient in a range of nutrients, vitamins and phytonutrients) causes 2.7 million deaths annually worldwide and is part of the top 10 risk factors contributing to mortality.

In general, about 400 grams/day of fruit and vegetables, except potatoes and other starchy tubers, are recommended by the World Health Organization (WHO) for the prevention of chronic diseases (LDL oxidation in atheroma plaque development, DNA oxidation and cancer, oxidation and ageing, inflammation, cardiovascular diseases) and alleviation of several micronutrient deficiencies: phytochemicals associated to health benefits include glucosinolates, terpenoids (carotenoids, monoterpenes, and phytosterols), and various groups of polyphenols (anthocyanins, flavones, flavan-3-ols, isoflavones, stilbenoids, ellagic acid and other phenolic acids). Their bioactivity has been associated to their antioxidant properties (capacity to scavenge free-radicals), which are involved in the onset development of many of the chronic degenerative diseases.

Epidemiological studies on the relationship between dietary habits and disease risk have shown that fruits have a direct impact on health: for example, an insufficient intake of fruits and vegetables causes around 14% of gastrointestinal cancer deaths, about 11% of ischaemic heart disease deaths and about 9% of stroke deaths in the world. Moreover, recent evidence suggests that micronutrient deficiencies (iodine, iron, zinc and vitamin B-12), which globally affect more than two billion people, increase disease susceptibility in all adult populations, reducing the productivity of workers, and may play a role in children's development compromising their cognitive capacity.

Obesity, a problem both in the developed and developing world, is best combated by increasing the consumption of fresh fruits instead of the use of processed foods with high starch and sugar contents. Increasing the consumption of fruit and vegetables is a practical strategy for consumers to optimize their health and to reduce the risk of chronic diseases: this recognition is spreading in the developed world and underscores the likelihood of increased demand. In contrast, diets with low micronutrient content could reduce children's mental and physical development and their performance in school, decrease work productivity, and enhance the poverty risk in the next generations.

Main phytochemicals with antioxidant and anti-inflammatory properties in common fruit species



A mix of fruit and vegetables add value to daily health

A balanced diet that includes deeply colored fruit and vegetables that provide vitamins, minerals, fiber and phytochemicals is needed to maintain good health, protect against the effects of ageing and reduce the risks of cancer and heart disease. Eating plenty of fruit and vegetables can help you ward off heart disease and stroke, control blood pressure, reduce risks of developing some cancers, avoid a painful intestinal ailment called diverticulitis, and guard against cataract and macular degeneration, two common causes of vision loss. The color of fruit and vegetables is important.

5+ A DAY

'5+ A DAY' is the name of a number of programs in countries such as Australia, France, Germany, United Kingdom, and the USA to encourage the consumption of at least five portions of fruit and vegetables each day. These programs follow the World Health Organization's suggestion to consume at least 400 grams of vegetables daily.

Red

Contain phytochemicals such as lycopene and anthocyanins with potential health-promoting properties. Includes: red apples, cherries, cranberries, red grapes, pink/red grapefruit, red pears, raspberries, strawberries, watermelons, beets, red peppers, radishes, red onions, red potatoes, rhubarb and tomatoes.

Orange and Yellow

Contain varying amounts of antioxidants such as vitamin C as well as carotenoids and bioflavonoids, which have health promoting potential. Includes: yellow apples, apricots, cantaloupes, grapefruit, gold kiwifruit, lemons, mangoes, nectarines, oranges, peaches, yellow pears, persimmons, pineapples, tangerines, melons, butternut squash, carrots, yellow peppers, potatoes (yellow fleshed), pumpkin, sweet corn, sweet potatoes and yellow squash.

White, Tan, and Brown

Contain varying amounts of phytochemicals, eg. allicin, found in the onion family. Includes: bananas, brown pears, dates, white nectarines, white peaches, cauliflower, garlic, ginger, Jerusalem artichokes, kohlrabi, mushrooms, onions, parsnips, potatoes (white fleshed), shallots, turnips and white corn.

Green

Contain phytochemicals such as lutein and indoles, which have potential antioxidant, and health-promoting benefits. Includes: avocados, green apples, green grapes, honeydew melons, kiwifruits, green pears, artichokes, asparagus, broccoli, brussel sprouts, cabbage, beans, celery, cucumbers, endive, leafy greens, leeks, lettuce, green onions, okra, peas, green peppers, spinach, watercress and zucchini.

Blue/Purple

Contain phytochemicals such as anthocyanins and phenolics, which have potential antioxidant and anti-ageing benefits. Includes: blackberries, blueberries, blackcurrants, purple grapes, plums, prunes, raisins, purple cabbage, eggplant, purple Belgian endive, purple peppers and potatoes (purple fleshed).

Food and Drug Industries Converge

Some fruit and vegetable species are only grown for their positive effects on human health. This new genre of products, called 'Nutraceuticals' (nutritive + pharmaceuticals), aims to prevent disease and includes a high number of foods recommended by doctors. The first nutraceutical products were energy drinks and probiotic yoghurts, but now the market is on the rise attracting the attention of important companies such as Nestlé, Danone and Pepsi because the plant-based health products may help to combat chronic diseases, such as diabetes, cardiovascular problems and Alzheimer's disease. There has been an explosion of consumer interest in health, enhancing the role of specific foods or physiologically active food components, making nutraceutical foods the leading trend in the US food industry and an emerging market in Europe, China and Japan (globally US$175 billion).

This development put horticulture-derived products in the same market as pharmaceuticals: it could be important to provide a new different market channel for horticultural products with better profit margins by about 20 to 25%. Food companies may prosper in the health-plant market if they will be closer to the customer, understanding their needs and monitoring their marketing success.

The Smartfood Project (box)

Epidemiological and experimental studies have demonstrated that only a small proportion of cancers are inherited. The environmental factors, including food poisons, smoking, infectious agents, radiation and pollutants, drugs and industrial chemicals are the most important causes of genetic modification: habits (including healthy diet) aimed to minimize the exposure to these carcinogens are known to protect us from cancer mutations. Some nutrients and physical activity have been demonstrated to be useful tools to prevent cancer and other aging-associated diseases by altering the functions of specific genes and inhibiting fat accumulation. Smartfood is a research and communication project (European Institute of Oncology, Fondazione IEO – CCM, Italy, Milan), aimed to develop nutritional improvement at different levels:

- identify bioactive compounds in foods interacting with longevity genetic pathways (smart food compounds);
- select the main foods enriched for these compounds (smart foods);
- validate the effects of "smart food compounds" and "smart foods" in disease prevention and cures, in model systems and humans;
- develop "smart food compounds" into dietary supplements or pharmaceutical drugs;
- promote good health by nutrition and primary prevention in the population (science communication).

Nutrition represents an effective tool to prevent cancer by reducing the intake of junk food and increasing the consumption of beneficial "smart" foods. Validating food components' healthy effects and selecting bioactive compound-enriched foods represent the new goals of nutrition research together with understanding the molecular mechanisms of how diets work.

CHAPTER EIGHT

BACK TO THE FUTURE OF HORTICULTURE: FROM ARCHAEOLOGY TO SPACE MISSIONS

S. De Pascale, R. Gucci

Introduction

Horticulture has always been of vital importance for mankind. Although it went through a period of decline due to the agricultural crisis in post-war decades, horticulture is now making a comeback as one of the pillars of human advancement in the global society of the 21st century. The evolution of dietary habits driven by increasing incomes, widespread access to information, and medical evidence demonstrating the beneficial role of fruits, nuts and vegetables, have changed consumers' perceptions and preferences both in developed and in developing countries. Nowadays, consumers are more and more aware of the crucial role played by a balanced diet with fruits and vegetables as a regular constituent of daily intake. Modern consumers have better knowledge about the properties and processes of horticultural products than in the past, and their demand for tasty, healthy products at a good price is increasing steadily. The benefits of horticulture are not limited to an improved diet or the mere value of its products as foods. The social role of horticulture and its relevance in art and history are very appreciated today. Therefore, horticulture can be considered a multifunctional industry that provides society with a wide array of services and products.

Horticulture is also rapidly evolving. The horticultural industry is poised to satisfy the demand by the global economy for food security and safety and as a way to improve health, and it is ready to meet the challenge of reducing environmental impact in an age of climate change. In this last chapter we have included a few inserts concerning some noteworthy points and the prospectives offered by horticulture in the future.

Renewed interest in the positive aspects of horticulture makes it likely that this discipline and its related industries will continue to play a major role in the future of civilization. Horticulture's mission can be summarized as "making fruits, vegetables, and plants available for better human nutrition in an environment which is more pleasing for people". We hope this will soon come true in all regions of our planet.

Horticulture and People

Since 2007, the world's urban population has exceeded its rural population, leading to a faster increase of poverty in the cities than in the countryside. Therefore, urban horticulture has become critical to improving food supply and safety, health, local economies, social integration, and environmental sustainability. Although the spread and importance of urban horticulture varies according to the market, social conditions, natural resources, labor availability, and climatic conditions in different countries, its impact is increasing (*Fig. 1*). Indeed, small urban gardens for horticultural purposes are spreading all over the world, including in Europe where urban gardens were often started following migration from rural regions to urban areas during the industrial revolution of the 19th century.

Figure 1 - Community gardens in Cuba (courtesy of G. Prosdocimi Gianquinto).

The so-called "migrant gardens" or "gardens of the poor" were developed to limit the negative effects of urbanization (poverty, social alienation, and malnutrition of workers and their families) in lands belonging to local administrations, factories, or religious communities. The availability of vegetables and farmyard livestock from those gardens became even more important in the first half of the 20th century, especially during the World War years when towns were isolated from the countryside and food was scarce.

After World War II, the evolution of socio-economic conditions shifted the original role of these gardens from food production toward recreational, educational, social, and environmental functions. Conversely, nowadays increasing public awareness about food safety issues has pushed their primary function toward food production again, coupling it with the ecological-environmental function of urban horticulture. This latter aspect is mainly due to the effects of "urban heat island" mitigation, urban waste recycling, transformation of city-owned vacant lots, urban requalification, and promotion of urban-rural linkage. Social and educational functions refer to a range of activities, such as those carried out with senior citizens and children (community and school gardens), not only with the aim of improving food security, but also establishing social contacts and overcoming loneliness, offering an opportunity for self-fulfillment during retirement, increasing knowledge, skills and positive attitudes towards nature and the environment. Horticultural training also improves job prospects and a sense of well-being and even decreases recidivism among prison inmates. Finally, although the psychological and health-related benefits of people-plant interactions have been well-known for centuries, Horticultural Therapy has been recognized as an important discipline to study and apply the effects of the horticultural activities on human well-being only in the last few decades. In 2006, the project 'Orti Urbani', began in Italy from a proposal by Italia Nostra and together with ANCI, the national association of Italian municipalities, the project has aimed to spread urban green culture and agricultural knowledge in the urban and suburban areas of cities, to limit degradation of the landscape, re-qualify the urban lifestyle, and allow better environmental quality *(Fig. 2)*.

Figure 2 - Community gardens in Bologna, Italy (courtesy of G. Prosdocimi Gianquinto).

Horticulture and Art

Horticulture and art are intimately related. As proposed by Jules Janick in his study "Horticulture and Art", this relationship has two facets: art in horticulture, the direct use of plants as pleasing visual objects; and horticulture in art, the use of horticultural products as subjects of artistic expression.

This latter concept is fundamental in various traditional forms of art. Vegetables, flowers, and fruits are considered beautiful objects in themselves, becoming motifs to adorn bodies, tables, homes, cities, and landscapes. Plants are also subjects of inspiration in most figurative arts: drawing and painting, sculpture, mosaic, photography, and tapestry. Indeed, the depiction of plants is a major theme in art. Plant imagery also appears in innumerable decorations, in floor and ceiling patterns, sculptural columns, silverware, ceramics, banknotes, and heraldry. In addition, the relationship between horticulture and art has generated unique disciplines including the floral arts, garden design, and landscape architecture.

The study of the images in works of art involving plants (plant iconography), from prehistory and antiquity to the present day, is a valuable source of information about plants and crops. There are numerous sources of plant iconography: cave paintings, ancient mosaics, sculptures, carvings and inlays, frescos, tapestries, illustrated manuscripts, herbals, books, and photography. They provide information on plant genetics, taxonomy, crop history, including evolution in nature and under domestication, as well as plant species diffusion and extinction. Specifically, crop images are unequivocal tools for assessing the historical presence of botanical taxa in a particular region, for determining morphological modifications of plants over time (e.g. the appearance of new traits depending on changes in climate and environment), and for research on crop evolution and diversity. This is especially true in prehistory, where images are older than writings.

Prehistoric stone works dating back to 30,000 years ago show evidence of clothing made from local plants: this indicates the development of textile technology in this ancient age.

Paintings from antiquity often depict plants and crops for their esthetic and/or symbolic value: plants can be found in caves, tombs, and temples as far back as 3000 B.C. The ancient technology of agriculture can be reconstructed from these artistic records. For example, the artistic genius of the Egyptian civilization combined with the favorable conditions of burial chambers and the dry climate of that region have made possible the reconstruction of a detailed history of agriculture in Ancient Egypt. The frescoes of Pompeii and Herculaneum, preserved by the eruption of Vesuvius in 79 A.D., offer valuable examples of depictions of plants in the Roman age. Paintings of plants became even more frequent during the Italian Renaissance. The genre of Baroque painting known as natura morta (still life) emphasized fruits, vegetables, and flowers and offers a rich source of information: sometimes the photo-like style makes it possible to identify diseases and insects. Illustrated manuscripts from antiquity also provide accurate agricultural representations, with scenes of the harvest of vegetables, fruits, flowers, grains, as well as culinary and medicinal herbs, providing information about life in different ages and the use of these products. Horticultural plants were a common motif of embroidery and tapestries, with the elaboration of textiles into decorated patterns used in various cultures. Printed herbals and woodblocks are other important sources of plant iconography.

More recently, horticultural plants have become a favorite subject of photography and art materials in dried flower compositions. In conclusion, the close relationship between horticulture and art is confirmed through a great amount of evidence that has been handed down through the centuries.

However, most of the works of art are scattered among libraries and museums, and are often difficult to locate and access. Recently, at the Department of Agricultural Sciences of the University of Naples Federico II, a collection of ancient prints dating back to the beginning of the last century, reproducing over 700 vegetable and fruit species has been made available online (http://www.centromusa.it/varort/) (*Fig. 3a, 3b, 3c, 3d*).

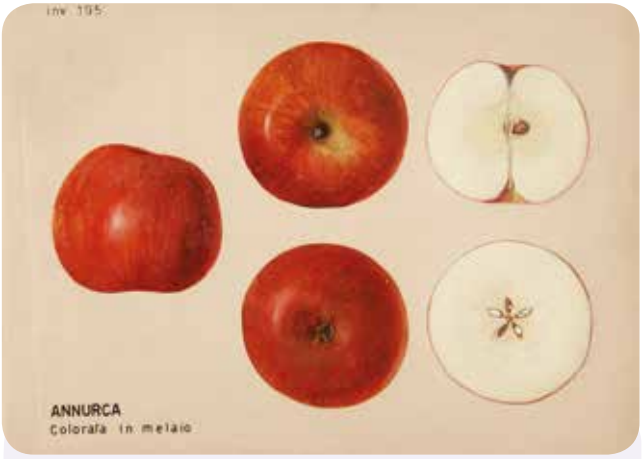


Figure 3a

Figure 3d

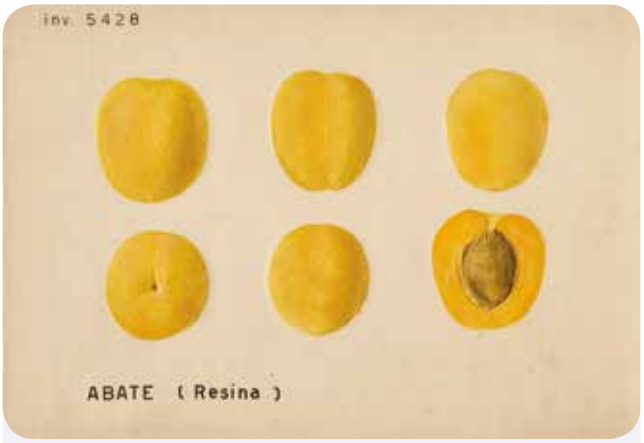


Figure 3b

Figure 3c

Figure 3 - Prints representing fruits of (a) apple (cv. Annurca), (b) apricot (cv. Monaco), (c) lemon (cv. Amalfitano), and (d) squash (cv. Zucca di Chioggia) belonging to one of the collections of the "Musei delle Scienze Agrarie – MUSA" Museum Center of the University of Napoli "Federico II" on display in the Royal Palace of Portici (Naples, Italy). The collection includes 700 watercolors representing the most important varieties of fruits and vegetables grown in Italy between the 19th and beginning of the 20th centuries.

Horticulture in Pompeii

Pompeii was a small city of about 20,000 inhabitants at the time it was buried under 4 to 6 m of ash and pumice in 79 A.D. by an eruption of Mount Vesuvius. Nowadays, the ruins of Pompeii represent one of the best examples of an ancient Roman town and provide, as if it were an open book, outstanding information on the domestic, social, and cultural life of its citizens. The archaeological, epigraphic, and literary records available offer a complete documentation of the arts, customs, trades, and everyday life in Pompeii. Apart from the main public buildings, Pompeii was a town of narrow streets with back-to-back groups of houses filling a block (insula). The architecture spans several centuries and the buildings testify to the evolution of domestic architecture, from the Italic model of the IV-III centuries B.C. to that of Imperial Rome in the I century A.D. The house (domus) consisted of an entrance space (atrium), with rooms placed around it, including the room of the master of the house (tablinum). In a typical Pompeian house of the IV and III century B.C., the space behind the house was reserved for the hortus, an enclosed space used for food production.

Starting in the II century B.C., the Pompeian house changed, it was embellished and became articulated on several levels. Also the hortus evolved, becoming a courtyard enclosed by an arcade with a colonnade all around (peristyle) (***Fig. 4***). The peristyle, with marble columns supporting the inner margins of the roof and forming the arcade, took the form of an ornamental garden (virdarium), adorned with flower beds, sculptures, fountains, and other works of art, and laid out with hedges and vines. It contained a wide variety of flowers: acanthus, cornflowers, crocus, cyclamen, hyacinth, iris, ivy, lavender, lilies, narcissus, poppy, rosemary and violet. Sometimes, one of the walls of the peristyle was decorated with paintings, depicting a view of imaginary gardens, seen through a false arcade (horti picti).

Figure 4 - Garden, House of the Golden Cupids (Amorini Dorati), Roman Ruins of Pompeii, Campania, Italy. With permission from the Italian Ministry of Cultural Heritage and Activities and Tourism Soprintendenza speciale per Pompei, Ercolano e Stabia. Reproduction or replication of this image is strictly forbidden in any form, by any means.

In this age, the hortus lost its functional value since the garden was enriched by ornamental plants with a decorative function, especially in the houses of the upper classes where it became clearly structured; however, it still preserved its ancient physiognomy and original productive function in the poorer residences.

After the Romans conquered Britain, a number of new plants were introduced, including roses, leeks, turnips, plums, and probably cabbages. They became masters of topiary art (ars topiaria), inventing and spreading the art of growing, cutting, and trimming trees or shrubs into odd or ornamental shapes, as well as the practice of miniaturizing plants (today known as bonsai). Boxwood, myrtle and rosemary, also used for their pleasant fragrance, were shaped into beautiful figures and replaced marble statues in the gardens of the not-wealthy. At the outset, irrigation was guaranteed by rain

water collected from roofs in underground cisterns, but the creation of the aqueduct in the age of Augustus made it possible to build greater fountains and water basins.

Stratigraphic excavation and ethnobotany, along with valuable writings such as Naturalis Historia by Pliny, have allowed us to trace back the origins of the Pompeii gardens, with detailed information about plant species and their multiple uses: from garden decoration to the making of crowns and garlands, to condiments, to medicine. The flowers available were cultivated in isolated groups or together with roses. The presence of exotic species in the Vesuvius area (lotus flowers, date palms, plantains, lemons and cedars) indicated long-distance trade. To decorate green spaces, gardeners used shrubs and trees, especially evergreens, which provided shade, background architecture and a pleasant smell. Apricot, peach, cherry, pomegranate, apple, pear, and plum trees were common in the gardens (*Fig. 5*). Extant frescoes depicting grapes are so precise that grape varieties can be recognized. Presses, amphorae, and wineries found in Pompeii testify to an abundant production of wine, and literary sources tell of a fine wine from Vesuvius. Olive trees were also grown: the oil was the basis for perfumes and ointments, while the wood was used to make inlaid furniture, the debris from milling fed the lamps, and the sludge was used to keep insects away from barns. The gardens of Pompeii were also known for pharmaceutical and perfumery production. In medicine, many ingredients were macerated in wine, the alcohol-base extracting the active ingredients, while fragrant species, such as lilies, roses and violets were intended for the preparation of perfumes. There were also fiber crops in the Vesuvian landscape: flax and hemp to make clothing, upholstery, sails and fishing nets, esparto for shoe soles and cordage, mats, baskets and shopping bags. Some plant species were employed as plant dyes and, depending on the fiber and the mordant used, they produced different colors. But the fury of Vesuvius canceled all this: it was August 24, 79 A.D., when the volcano buried Pompeii under a thick carpet of volcanic ash and killed all of the inhabitants but preserved the town almost entirely intact for posterity.

Figure 5 - Garden of the Fugitive (Orto dei Fuggiaschi), Roman Ruins of Pompeii, Campania, Italy. With permission from the Italian Ministry of Cultural Heritage and Activities and Tourism Soprintendenza speciale per Pompei, Ercolano e Stabia. Heritage and Activities and Tourism - Soprintendenza speciale per Pompei, Ercolano e Stabia. Reproduction or replication of this image is strictly forbidden in any form, by any means.

Sustainability and Precision Horticulture

As our climate changes, horticultural crops are forced to face different environmental conditions. In Italy, it is expected that temperatures will rise especially in central and northern regions and that precipitation will become more erratic in occurrence and intensity. Climate change may also make traditional areas of cultivation unsuitable for crops that have long been grown there, thus forcing a process of crop migration to more favorable areas. Abiotic and biotic stresses determine direct damage and product losses, reduced yields, and altered qualitative characteristics, while the replacement of species, development of new cultivars, methods to better acclimate plants,

and technologies to alleviate stress can make horticulture still viable in areas subjected to climate change. Drought, salinity, waterlogging, and temperature stress are common threats for horticultural crops, especially for perennial crops. Breeding for new cultivars is a common remedy to cope with increasing stress and, in this respect, traits that can confer stress tolerance or resistance can often be found in old cultivars that are sometimes only present in germoplasm collections. Understanding the molecular and physiological mechanisms underlying plant responses to single or combined stresses is also important. Cultural practices can help alleviate stress: irrigation against drought, nutrition against mineral deficiencies, drainage against waterlogging, nursery acclimation to reduce losses during transplanting, choosing crops that demand less water, nutrients, protection, or labor.
A substantial contribution to dealing with stress can come from precision horticulture, whereby high-resolution images make it possible to draw maps that report the spatial and time needs of crops with regard to water and nutrients. Today, monitoring crop growth and vegetative activity is possible using satellite images, small airplanes, or UAV (unmanned aerial vehicles also called drones). Airplanes and satellites can collect data over vast areas in a short time, but the time resolution is too low to be used in precision horticulture. For this reason, and because most horticultural crops are often grown over relatively small areas (i.e. fields) UAV carrying spectroradiometry cameras appear more suitable for environmental and productivity assessment.

Space Horticulture

Horticulture in space is considered both a need and a pleasure. In fact, growing plants in space could make it possible to renew resources in space outposts as well as provide psychological benefits to astronauts. Long-duration manned missions in space, such as future travel to Mars or human permanence in orbital or planetary stations, are based on the renewal of resources (e.g. oxygen, water, and food), which are currently brought from Earth. However for the longer missions we expect to carry out in the future, this will not be possible due to economic and practical constraints. Considering that each crewmember would need, on average, 30 kg of resources per day, even frequent re-supplying of consumables and the corresponding disposal of wastes would be costly and difficult. Moreover, increased mission duration will worsen the sense of isolation suffered by astronauts. The psychological support offered by horticulture will be increasingly important for future space exploration because it will contribute to creating a green, Earth-like environment that can alleviate stress. Indeed, since the first experiments on plants in space, astronauts have been cheered by dedicating some of their intensely scheduled time to plant cultivation. The crew's health also relies on the possibility of integrating fresh food produced onboard into their diet. Currently, food preparation and packaging still represent crucial aspects for food consumed in space as it must be solid to avoid the dispersion of crumbs (which could be inhaled or damage equipment) due to reduced gravity, and as dry as possible to slow decay and to prevent bad odors. During storage, changes may occur in organoleptic (taste, color, firmness) and nutritional (e.g. vitamin content) attributes, making food less attractive and healthy. The need for proper nutrition during space travel is even more important considering that reduced gravity and high levels of radiation can predispose crew members to several health problems (e.g. osteoporosis, muscle atrophy, DNA aberrations, development of tumors), the risk of which can be reduced by the consumption of functional compounds from plants (e.g. antioxidants from tomatoes and proteins from soybeans). It goes without saying that human residence in space depends on the development of a Bioregenerative Life Support System (BLSS), allowing the continuous regeneration of system resources and the recycling of wastes. BLSSs are closed or semi-closed artificial ecosystems based on the exchange of materials and energy among several compartments, hosting different organisms (e.g. mammals, fishes, plants, bacteria) in an ideal food chain in which each one uses the wastes of the others.

Plants are the most promising organisms for BLSSs at the moment, due to their complementary relationship with humans. Indeed, in a simplistic vision, plants can regenerate air by absorbing carbon dioxide and producing oxygen through photosynthesis, purify water through transpiration, and produce fresh food (in the case of crop species) by using human wastes. BLSSs must be efficient and growing conditions optimized. Several plant species and cultivars, often complementary for their nutritional properties, have been studied as candidate crops for BLSSs (bread and durum wheat, potatoes, soybeans, tomatoes). The development of growth chambers, equipped for precise climate control, is crucial for preparatory ground-based experiments. BLSSs have not yet been used in space because of economic and technical constraints. Their high-energy consumption, large volume required, and weight have limited their development to ground-based demonstrations.

Figure 6 - Flight hardware of the SAYSOY (Space Apparatus to Yield SOY sprouts) ESA project: germination chamber (upper module), hydraulic system (middle level), and electronic system (basal module). The experiment was performed to investigate the possibility of producing soy sprouts onboard to integrate a crew's diet during long-term missions and/or permanence on space stations, and conducted successfully by the team of prof. Veronica De Micco and Giovanna Aronne of the Department of Agricultural Sciences of the University of Naples Federico II, during the Foton-M2 campaign (31 May 2005 through 16 June 2005).

In the near future, their development will remain limited to the production of some fresh foods for dietary integration and to the study of plant productivity and physiology under space conditions for research purposes. However, later planetary bases could rely on resources and environmental conditions to build larger-scale BLSSs able to provide partial autonomy for space colonies or outposts. The production of crops in BLSSs will likely be based on soilless (or hydroponic) culture techniques *(Fig. 6)*. In these systems, plants are grown on solid substrates or in empty containers without natural soil and are fed with diluted nutrient solutions containing mineral elements. Among soilless systems, cultivation on substrates and Nutrient Film Technique (NFT) are the most commonly used in space-oriented experiments. In the former case, physically and chemically inert materials (e.g. rockwool) are used to exploit substrate water retention and ion exchange, and to facilitate the precise dosage of water and nutrients.

In NFT, plants are suspended in slightly sloping channels in which the nutrient solution flows by gravity through the roots and it is recovered and redistributed by a submerged pump. Horticulture in BLSSs in ground-based demonstrations is a complex matter made even more complicated in space where multiple constraints act together, such as the limited weight and volume available in space vehicles, and the reduced gravity, which is responsible for a lack of convective air movement that ultimately affects, gas-exchanges and can trigger hypoxia in the root zone. Altered fluid dynamics in space require the development of dedicated technologies or the improvement of already-existing expertise to fertigate crops; the driving force for water distribution (e.g. capillarity-based systems) needs to be further developed. Reduced gravity (1/6 g on the Moon and 1/3 g on Mars) could make the adoption of gravity-driven irrigation strategies possible, thus solving problems in orbiting space stations.

Altered gravity and high levels of radiation can also be perceived as stressors by plants, causing alterations in the structure and functioning of various organs. Such alterations, even when not so severe as to impede the organism's survival, can still lead to a reduction of productivity and variations in the quality of plant organs to be used as fresh food by astronauts (*Fig.s. 6, 7*).

Figure 7 - Foton-M2 satellite flown in May-June 2005 during sample retrieval in Kazakistan.

Italian Food, Italian Style (box)

Horticultural products and the foods derived from them are currently as fashionable as luxury goods or artwork. Consumers, and the young in particular, appreciate the high quality of Italian food, which in recent years has become a lifestyle "must". Italian dishes prepared according to traditional, regional or revisited recipes are trendy in restaurants, hotels, and homes worldwide. Italian cuisine is widely based on fresh or cooked horticultural products and Italian foods are so popular that they are copiously imitated. Counterfeited foods amount to 60 billion euro per year, twice that of Italian exports. This fraud has become a major threat to the work of millions of honest growers and processors.

The food industry is one of the leading economic sectors in Italy, with a total revenue of about 130 billion euro, almost 10% of the national GDP. As for horticulture, it is estimated that the nursery production of trees (fruit and ornamentals) employs 114,000 people, and its value amounts to 1.5 billion euro. About 2.5 million ha are cultivated with fruit trees, grapevines or olive trees, and a vast array of varieties is presently grown in fields or germoplasm collections. It is estimated that 24,516 accessions belonging to 74 genera and 446 species are conserved ex situ in Italy and an additional 2,134 horticultural accessions are conserved on farms. These impressive numbers are the basis for the 143 PDO and PGI designations (99 fruit, 44 vegetable) that have been granted to Italian horticultural products. All this genetic wealth requires considerable financial and human resources. Germplasm collections need to be taken care of and plants need to be replaced when old or dead, while funding is currently scarce and rests on the shoulders of public institutions. The public is only partially aware of the importance of preserving these sources of genes and diversity for future generations: the benefit is not merely commercial as old varieties can help to improve food for the future or to develop plants that are more resistant to diseases and pests. The trend towards healthier and tastier foods is spreading to many countries. Recent surveys show that high quality products rank first among attributes influencing consumers. In this respect, horticulture is a driving force for economic development and employment and we hope Italy will maintain its leading role of spreading the culture of "good, healthy food."

THE ITALIAN SOCIETY FOR HORTICULTURAL SCIENCE

The SOI (Italian Society for Horticultural Science, www.soihs.it) is one of the largest horticultural societies in the world in terms of number of associates and activities, and one of the main scientific societies dealing with agriculture in Italy. It *promotes studies, research and initiatives aimed to foster the progress, diffusion and growth of horticulture*. Areas of interest include fruit trees, vegetable and flower crops, nursery production, design and management of urban areas, turfgrass, and the management and preservation of agricultural landscapes.

The Society was established in Florence, at the "Accademia dei Georgofili" in 1953. Prof. Alessandro Morettini was elected the first president and chaired the Society until 1973. Over the last 64 years, nine presidents have run the SOI. Two of them, Franco Scaramuzzi (1973-1985) and Silviero Sansavini (1985-1991), have also become Presidents and Honorary Members of ISHS.

SOI participates in ISHS activities both as a Society and through its individual members (for instance, at the moment 5 Italians are serving as the vice-chair of the ISHS or as Section/Commission chairs without taking into considerations Section/Commission vice-chairs and working group chairs). A large number of Symposia have been organized in Italy by SOI members as part of ISHS activities (for instance, during the last year, 49 ISHS Symposia were organized in Italy), including the IHC held in Florence in 1990).

SOI is managed by a General Board (*Consiglio Direttivo Generale*) coordinated by the General President, and by the General Secretary. The activities are carried out thanks to the "Fruit Section" (*Frutticoltura*) and the "Vegetable-ornamental Section" (*Orto-florovivaismo*), with each one being run by a section chairman. In addition, a dozen Working groups are active (http://www.soihs.it/soi/gruppi_di_lavoro.aspx) with specific technical and scientific identities. Locally, the activities of the Society are supported by regional delegates.

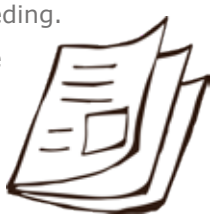
Our members include a vast array of professional categories, such as scientists, professors, graduate students, growers, consultants, nurseries, producer boards, public administrators, and companies trading horticultural products.

SOI promotes and organizes studies and research, organizes symposia, workshops, technical meetings, and highly qualified courses for graduate students and young scientists. As an independent organization of horticultural experts, SOI advocates the development of a sustainable horticulture for the progress of the Society as a whole. To this end it also takes positions on the main issues related to horticulture and offers opinions.

Each year, the Society, especially through its Working Groups, organizes many horticulture-related national and regional events, congresses, exhibitions and workshops (185 in the last 10 years).

Since 1992, SOI regularly organizes its "Scientific Days" (*Giornate Scientifiche SOI*), the most important scientific meeting devoted to horticulture in Italy. The eleven editions carried out so far, all around the Country, had an average attendance of around 400 delegates each. On top of that, SOI has organized "Technical days" (*Giornate Tecniche SOI*) and other events at a national level on specific technical issues related to horticulture.

SOI has published more than 250 books, booklets and proceedings, most of them resulting from seminars, scientific and technical workshops or congresses organized by the Society to address scientific, technical and management issues regarding fruit, vegetable and flower culture and breeding.



Since 1993, the Society publishes "*Italus Hortus*", its official journal, now available in an open access format (http://www.soihs.it/italushortus/english.aspx), featuring reviews of principal horticultural subjects, in Italian or in English. SOI also publishes proceedings of symposia named *Acta Italus Hortus*, as well as technical handbooks.

Massimo Tagliavini
President

Maurizio Lambardi
General Secretary

LIST OF CONTRIBUTORS

Giuseppe Barbera
Dipartimento di Scienze Agrarie, Alimentari e Forestali
Università degli Studi di Palermo
Email: giuseppe.barbera@unipa.it

Gabriele Loris Beccaro
Dipartimento di Scienze Agrarie, Forestali e Alimentari
Università degli Studi di Torino
Email: gabriele.beccaro@unito.it

Giancarlo Bounous
Dipartimento di Scienze Agrarie, Forestali e Alimentari
Università degli Studi di Torino
Email: giancarlo.bounous@unito.it

Ferdinando Branca
Dipartimento di Agricoltura Alimentazione e Ambiente
Università degli Studi di Catania
Email: fbranca@unict.it

Luigi Catalano
AGRIMECA Grape and Fruit Consulting
Turi - Foggia
Email: l.catalano@agrimeca.eu

Giancarlo Colelli
Dipartimento di Scienze Agrarie, degli Alimenti e dell'Ambiente
Università di Foggia
Email: giancarlo.colelli@unifg.it

Giuseppe Colla
Dipartimento di Scienze Agrarie e Forestali
Università degli Studi della Tuscia
Email: giucolla@unitus.it

Stefania De Pascale
Dipartimento di Agraria
Università degli Studi di Napoli Federico II
Email: stefania.depascale@unina.it

Petra Engel
Consiglio per la Ricerca in Agricoltura e l'Analisi dell'Economia Agraria
Centro di ricerca per la Frutticoltura
Email: petra.engel@gmail.com

Franco Famiani
Dipartimento di Scienze Agrarie, Alimentari e Ambientali
Università degli Studi di Perugia
Email: franco.famiani@unipg.it

Carlo Fideghelli
Consiglio per la Ricerca in Agricoltura e l'Analisi dell'Economia Agraria
Centro di ricerca per la Frutticoltura
Email: isfrmfid@gmail.com

Riccardo Gucci
Dipartimento di Scienze Agrarie, Alimentari e Agro-ambientali –
Università di Pisa
Email: riccardo.gucci@unipi.it

Paolo Inglese
Dipartimento di Scienze Agrarie, Alimentari e Forestali
Università degli Studi di Palermo
Email: paolo.inglese@unipa.it

Maurizio Lambardi
Istituto per la Valorizzazione del Legno e delle Specie Arboree
CNR - Dipartimento Agroalimentare - Sesto Fiorentino
Email: lambardi@ivalsa.cnr.it

Cherubino Leonardi
Dipartimento di Agricoltura Alimentazione e Ambiente
Università degli Studi di Catania
Email: cherubino.leonardi@unict.it

Davide Neri
Dipartimento di Scienze Agrarie, Alimentari e Ambientali
Università Politecnica delle Marche
Email: d.neri@univpm.it

Silvana Nicola
Dipartimento di Scienze Agrarie, Forestali e Alimentari
Università degli Studi di Torino
Email: silvana.nicola@unito.it

Carlo Nicoletto
Dipartimento Agronomia, Animali, Alimenti, Risorse Naturali e Ambiente
Università degli Studi di Padova
Email: carlo.nicoletto@unipd.it

Maria Antonietta Palombi
Consiglio per la Ricerca in Agricoltura e l'Analisi dell'Economia Agraria
Centro di ricerca per la Frutticoltura
Email: mariaantonietta.palombi@crea.gov.it

Giorgio Prosdocimi Gianquinto
Dipartimento di Scienze Agrarie
Università di Bologna Alma Mater Studiorum
Email: giorgio.gianquinto@unibo.it

Daniela Maria Maura Romano
Dipartimento di Agricoltura Alimentazione e Ambiente
Università degli Studi di Catania
Email: dromano@unict.it

Paolo Sambo
Dipartimento Agronomia, Animali, Alimenti, Risorse Naturali e Ambiente
Università degli Studi di Padova
Email: paolo.sambo@unipd.it

Silverio Sansavini
Dipartimento di Scienze Agrarie
Università di Bologna Alma Mater Studiorum
Email: silviero.sansavini@unibo.it

Valentina Scariot
Dipartimento di Scienze Agrarie, Forestali e Alimentari
Università degli Studi di Torino
Email: valentina.scariot@unito.it

Oriana Silvestroni
Dipartimento di Scienze Agrarie, Alimentari e Ambientali
Università Politecnica delle Marche
Email: o.silvestroni@univpm.it

Massimo Tagliavini
Facoltà di Scienze e Tecnologie
Libera Università di Bozen-Bolzano
Email: massimo.tagliavini@unibz.it

Pietro Tonutti
Istituto di Scienze della Vita
Scuola Universitaria Superiore Sant'Anna
Email: pietro.tonutti@santannapisa.it

Harvesting the Sun Italy

ISBN: 978-88-940276-5-5 - Price for non-member of SOI: € 25