TRUFFLE CULTIVATION

Truffles are fruit bodies produced by hypogeous fungi of the genus *Tuber* (Ascomycetes) that in Nature are spontaneously formed in certain environments, in association (mycorrhizal symbiosis) with some forest plants such as oaks, hornbeams, hazelnut trees, linden trees, cedar trees, pines, poplars and willows. This symbiosis, observed in both arboreous and herbaceous plants, leads to the formation of structures known as mycorrhizae, through which both organisms achieve a mutual benefit for their development.

Root apexes with visible mycorrhizae of ***Tuber uncinatum***

On the basis of nowadays knowledge it is possible to induce a symbiosis between various plants and several *Tuber* species (mycorrhized plants). These plants, cultivated on soils suitable to both plant and truffle, can produce fruit bodies (carpophores) identical to those found in Nature.

The term “truffle cultivation” therefore indicates the “specialized” cultivation of mycorrhized plants, obtained by the constant application of specific cultivation techniques, which are the results of the research work carried out so far. Among the numerous truffle species present in Europe, only a few show a commercial interest: the white truffle (*Tuber magnatum* Pico), the rare black truffle (*Tuber melanosporum* Vitt.), the winter truffle, and mainly the *Moscatum* truffle (*T.brumale* Vitt. and *T. brumale* Vitt. *var. moschatum* De Ferry), the summer truffle (*T. aestivum* Vitt.), the *Uncinatum* truffle (*Tuber aestivum* Vitt. *forma uncinatum* Chatin) and various truffles among the *Tuber borchii* Vitt. group.

Mycorrhization is usually performed in laboratories under sterile conditions, through techniques that are constantly updated on the basis of the research progresses. The truffles used for this purpose must be well ripened (spore inoculation) and must preferably come from the same or similar environments to those where the mycorrhized plants are going to be transplanted.

During every step of the inoculation, and also during the plant growth in green houses and in nurseries, a high degree of asepsis must be guaranteed, to avoid any contamination by spores of other antagonistic fungi. Periodical examinations under a light microscope are useful to evaluate from both a qualitative and a quantitative perspective the level of mycorrhization achieved.

Truffle-producing plants in a green house

Every year, all the plants present in the garden centre must undertake quality controls, to verify their degree of micorrhization, prior to their marketing.

Mycorrhizae of ***Tuber melanosporum*** Vitt.

Quality controls should be carried out by public organizations of reknown professionality (Universities, Research Centres, etc) rather than by private bodies, where a conflict of interest may exist. Only well developed plants, characterised by a good foliage to root system ratio, will be commercialised with the truffle cultivation suitability certification, once the root mycorrhization will have reached the standard level.

In various specialized European green centres the following wood and shrub plants are mainly available, mycorrhized with truffle species with similar nutritional needs:

Corylus avellana – Hazelnut tree	***Ostrya carpinifolia*** – Hop hornbeam
Pinus halepensis – Aleppo pine	***Pinus pinea*** – Italian stone pine
Quercus cerris – Turkey oak	***Quercus ilex*** – Live oak
Quercus pubescens – Truffle oak	***Quercus robur*** – Bay oak
Tilia cordata – Linden tree	***Cistus incanus*** – Pink rockrose

A basket of truffles produced by ***Tuber magnatum*** Pico

THE MAIN TRUFFLES (in a decreesing order of commercial value)

Tuber magnatum Pico – White truffle. It shows a smooth, light yellow or slightly greenish peel (*peridium*), a more or less dark nut-brown flesh ("gleba"), sometime accompanied by a vivid red nuance. It is characterised by a typical and pleasant intense fragrance. It ripens between September and the end of December.

Tuber melanospoum Vitt. – Rare black truffle.
It shows a rough, dark brown peel characterised by tiny warts. The ripe flesh is violet-black with white and fine vains, which become reddish when exposed to the air and black after cooking. It has a typical, very pleasant fragrance. It ripens between the middle of November and the middle of March.
Tuber brumale Vitt. *var. moschatum* De Ferry – *moscatum* truffle.
It shows a rough black peel, easily detachable, characterised by tiny warts; the flesh is dark with large white vains. Its size never exeeds that of a hen egg. It has a strong particular fragrance and a hot taste. It ripens between January and March.

Tuber aestivum Vitt. *forma uncinatum* Chatin – *uncinatum* truffle.
It shows a black, warty peel with white pyramidal warts. The flesh is chocolate brown with light nut-brown branched vains. It has a typical delicate and pleasant fragrance. It ripens between October and February.

Tuber aestivum Vitt. – Summer truffle.
It shows a warty, dark grey or black peel, with large, pyramidal warts. The gleba is yellowish – bronze, with light vains. It has a weak fragrance. It usually produces medium to large carpophores. It ripens between June and October.

Tuber borchii Vitt. – *borchii* truffle.
It shows a smooth, beige to fulvous peel; the flesh is light coloured, with fulvous-violet nuances and beige round branched vains. It has a garlic-like aroma. It ripens between January and the middle of April.

A young truffle plantation of Turkey oaks mycorrhized by the rare black truffle

THE RIGHT ENVIRONMENT

Prior to planting a truffle bed, it is necessary to undertake a pedological, climatic and orographic analysis of the area, to evaluate its suitability. The choise of both the most suitable truffle species and forest plant is based upon the data obtained. Here are some information of the right environment and the requirements of the commercially most interesting truffle species. All the information refers to Italian environments.

Black truffles (rare black truffle, moscatum truffle, uncinatum truffle, summer truffle)

These truffles occupy a widespread area all over Italy, in particular they are found in Umbria, Marche, North Lazio, Abruzzo, Molise and other regions of both North and South Italy, due to the merging of optimum environmental factors. The present knowledge on truffle biology, and in particular on that of black truffles, suggests that also in other Italian regions truffle cultivation may be possible.

The rare black truffle, in particular, prefers extremely thin, calcareous soils, derived from rocks of the Mesozoic era, characterised by an alcaline pH (pH 7,6-8,2), abundant gravel and stones, a fair clay content, good permeability, a low or average humus, nitrogen and potassium content, a sufficient supply of phosphorus. The most suitable areas are placed at an altitude between 400 and 1000 m a.s.l., with a slope to avoid stagnant water, exposed to South, South-East or South-West in North-Central Italy; esposed to North, North-East or North-West in South Italy. The peculiar biology of the black truffle, able to develop in dry and impervious areas, allows to appoint for truffle cultivation the most marginal fields, unsuitable to traditional farming activities.

The white truffle. This truffle shows a more limited distribution area, due to its greater needs as compared to those of the black truffle; it requires fresh soils, located in bottom valleys, preferably along streams and rivers, characterised by a clay marl geological origin, a sub-alcaline pH (pH 7,5-8) and a medium fertility. Soils must be recently formed, located at a maximum altitude of 800 m a.s.l., in areas characterised by over 900/1000 mm of rain per year, on level lands or with a NE or NW exposure. These properties are met in precise micro-environments found in North-Central Italy. Current knowledge cannot suggest to invest in this kind of truffle plantation. Nowadays its cultivation can only be promoted for experimental purposes, until the current research work will elucidate the *Tuber magnatum* biology.

Borchii truffle. This truffle is less demanding in terms of environmental needs than the white truffle, and it is therefore more present both in plains and in mountains, up to over 1000 m a.s.l. It prefers sandy soils with a sub-acid to sub-alcaline pH (pH 6,2-8,2) and it is often associated with conifer plants as symbionts.

Left side: *Tuber magnatum* Pico – White truffle
Right side: *Tuber aestivum* Vitt. *forma uncinatum* Chatin – *uncinatum* truffle

CULTIVATION TECHNIQUES

The success of a truffle plantation depends on several factors, including the plantlet quality. Plants must therefore be purchased from producers that can guarantee an optimum quality by selling plants accompanied by a plant certificate (see European Directive 1999/105/CE and the following legislation applied in each European country) and a mycorrhization certificate, both issued by reliable public organizations.

A truffle bed plantation. Prior to transplanting, local forest and shrub plants must be removed, if present, in order to limit competition by other fungi present in their root systems. This preparative work must be carried out in spring. When possible, it is advisable to plough the field in summer, at a medium depth, when the soil is in temper, to obtain a good clod turning and the interring of the most superficial soil layer, generally rich of antagonistic fungi. Rippering can be done first, at a major depth, as long as the various soil layers are not mixed. The soil long summer exposure to the sun favours exogenous fungal spore and mycelium devitalization. Just before transplanting, harrowing is recommended.

Mycorrhized plantlets, divided by truffle species, can be transplanted either at the beginning or at the end of winter. It is important to carefully remove the pot in order not to damage the mycorrhized root apexes. The best technique envisages to tranfer the plantlets in hollows (30x30 cm) the bottom of which is covered by gravel, hollows being consequently filled with the removed soil.

A truffle oak-plantation which has been producing rare black truffles for many years

It is possible to use plants of a single species, as a typical forest mono-culture, or associations among various species with a different productive cycle (plants decrease their productivity when they reach senility) and a different production starting time. The plantation density depends on the forest plant and the truffle species utilized. As an indication, oaks have a plantation density of 300-500 plants per hectare when placed in a square pattern or in alternate rows. A lower density is preferable in level fields, with N-S orientated rows.

Cultural care. Neither chemical weeding nor organic or mineral fertilizations are required. During the first three years of the plantation, localized hoeing around plants is necessary to halt weeds, or alternatively a superficial harrowing. Aid watering must be planned during summer; in case of lack of water, a soil covering with straw must be accomplished, making sure to remove it before winter. During the third year plant pruning can start, to remove the lower branches for a better sun ray penetration at the basis of the trunk, and to model the foliage into a reverse cone shape. Pest control can only be carried out against insects. Systemic fungicides against microbial pests must be avoided.

A basket of truffles produced by *Tuber aestivum* Vitt. *forma uncinatum* Chatin – *uncinatum* truffle

PRODUCTION

Several factors can influence truffle production (truffle and plant symbiont species, pedoclimatic characteristics of the site, etc). For this reason it is not possible to precisely indicate after how long the plantation will start producing truffles. As an indication, oak trees, which are tough plants but with a slow growth rate, start to produce usually after ten years from the plantation.

Plants characterised by a faster growth rate, such as hazelnut trees or hornbeams, with more requiring environmental needs, can sometime start producing earlier. As a consequence it is difficult to predict a truffle plantation profit.

When in a truffle plantation all the optimum productivity factors are met, such as certified quality of both plants and mycorrhization, an environment suitable to both the selected species and to the maintenance of the symbiosis with the desired truffle, the benefit will be certaintly superior to that derived from traditional farming activities. This is particularly true considering that lands suitable to truffle production are also those scarsely fertile, where intensive farming would not be possible. In order to obtain satisfying results, though, constant and appropriate cultural care must be guaranteed.

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