

State of the art in truffle knowledge and cultivation in Italy

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Abstract. The presence of truffles in Sicily and perspectives for their cultivation on the island are assessed, with a brief analysis of basic and applied research on truffles and truffle cultivation in Italy, focusing on successful production and on reasons for failure in some artificial truffle-beds. Truffle cultivation has progressed in recent decades and there is now sufficient know-how for creation of productive truffle plantations. Further research is needed on host plant growing techniques.

Key words: cultivated truffle-bed, Italy, truffles, *Tuber*

Introduction

In recent decades interest in truffles and truffle cultivation has increased in Italy and, in particular, in Sicily, where research has begun aimed at verifying the presence, frequency and ecology of truffles, and evaluating local cultivation possibilities.

The presence of truffles in Sicily was demonstrated some already years ago (Venturella 1995). Ongoing investigations have revealed the presence of several species, among which the most common (and surely cultivable) are the summer truffle (*Tuber aestivum* Vittad.) and bianchetto (*T. borchii* Vittad.). The more valued white truffle (*T. magnatum* Pico) may also be present in rare and small habitats on mountain slopes, though this has not yet been proved. A search should therefore be undertaken to assess the possible presence of the white truffle and other valuable species like the black truffle (*T. melanosporum* Vittad.), which may already have been produced in Sicilian cultivated truffle-beds. Future development of truffle cultivation will need to observe results of research aimed at defining the most suitable sites, host plants, pre-planting agricultural techniques, host-plant density and distance, and the best treatment of host plants during their initial growth and subsequent production phase.

State of the art in basic research in Italy

In the last twenty years basic and applied research has been oriented to fine-tuning and definition of cultivation techniques for truffles. Initial research dealt with mycorrhization in host plants and consequent yield results. The first artificial mycorrhization was performed in Turin at the Ceruti school (Fontana 1967) obtaining a symbiosis between *Tuber maculatum* Vittad. and *Pinus strobus* L. at the same time, Mannozi-Torini (1970) performed some greenhouse mycorrhization tests on oak (*Quercus pubescens* Willd.) with *Tuber melanosporum*. In the same period a number of other mycorrhization tests took place (Palenzona 1969; Fontana & Bonfante-Fasolo 1971; Palenzona *et al.* 1972; Fontana & Giovannetti 1979; Palenzona & Fontana 1979), but it was not until the eighties that a revised essay on mycorrhization techniques was published (Bencivenga 1982). That essay fostered development of large-scale production of inoculated plants in greenhouses. Research on truffle mycorrhizal morphology has made it possible to recognize the mycorrhizae of different species: this is necessary to assess the quality of commercialized inoculated plants (Bencivenga & Granetti 1990; Zambonelli *et al.* 1993; Bencivenga *et al.* 1995;

Granetti 1995). More recently, to confirm morphological observations, biomolecular research on mycorrhizae has been conducted (Paolocci *et al.* 1997, 1999; Rubini *et al.* 1998, 2004). Studies on morphology have led to production, in 1995, of a protocol, commissioned and adopted by various Italian regions, for assessment and certification of inoculated plants: The protocol was preceded by a proposal for a method of analysis published by the Italian Ministry of Agriculture (Bencivenza *et al.* 1987). Controlled and certified mycorrhized plants are thus now available.

Cultivation of such plants supposes knowledge of sites suitable for truffle production. A search for such sites in traditional truffle growing areas was performed by experts in botany and pedology: in particular botanists surveyed plants present on individual truffle-beds (the actual spots where truffles are collected) while pedologists dug profiles and took soil samples at various depths. Rainfall and temperature data were obtained from the recording stations nearest each site. The results of such investigations have been published in a variety of places, and have encouraged improved planting and cultivation techniques for artificial truffle-beds, and development of techniques to regain or improve yield in natural truffle-beds.

The present situation in applied research

Truffle cultivation in Italy is of ancient origin. Direct cultivation tests were attempted in the 15th and 17th century. Francolini (1932), a fore-runner in developing artificial mycorrhizal associations, to avoid damage by rodents to young oaks, soaked acorns with ground truffle, germinating them in a greenhouse, then transplanting the seedling to the fields. Truffle-producing plants were later developed and produced by Mannozi-Torini, who can be considered the pioneer of Italian truffle cultivation. With a simple yet effective technique, he grew young plants of oak (*Quercus pubescens*) with artificially induced mycorrhizae of the black truffle (Mannozi-Torini 1970).

Researchers are now studying the ecological requirements of truffles authorized for cultivation and marketing in Italy. They are also looking at cultivation techniques for host plants aimed at maintaining and increasing the presence of mycorrhizae on roots. Though plants with artificially induced mycorrhizal associations were already available in the 1970s, truffle cultivation only really spread in the 1980s, mainly due to promotional activities by commercial plant nurseries which had started producing host plants. Believing that truffle cultivation would be guaranteed with the purchase of guaranteed mycorrhized plants, a great number of truffle plantations were created in the 1980s and 1990s all over Italy, often with little consideration paid to environmental conditions of the planting site. In this period, beside commercial nurseries selling host plants, there were also unscrupulous dealers promising exaggerated yields, and ill-informed technicians recommending a wide range of often

mistaken agricultural operations. At the same time an increase in truffle consumption took place following promotion by various local agencies.

This chaotic development of truffle cultivation brought different results: some cultivated truffle-beds produced a good yield; others had little or no production. Reasons for failure lay in use of:

- a) non-mycorrhized host plants;
- b) unsuitable soils;
- c) incorrect host species or cultivation techniques.

Failures lamented by farmers, and secret successes of some fortunate truffle-growers, resulted between 1999 and 2000 in something of an oblivion for truffle cultivation. It returned to fashion in the 2002/2003 season, however, when, thanks to favourable weather conditions most previously under-productive artificial beds started to yield good quantities of truffles. In 2003 demand for truffle-inoculated plants was strong, and Italian commercial nurseries were unable to provide such high numbers of plants, so that French producers covered the demand.

Production of cultivated truffle-beds

Tuber melanosporum

About 80 % of truffle beds show production of some kind, of these about half provide scarce yields (1-10 kg/ha) while the other half bring satisfactory yields (15-50 kg/ha) with top production rates of more than 100 kg/ha.

Tuber magnatum

No steady yield; cultivated beds in which sufficient conditions of moisture, shade, and soil softness have developed, are starting some production.

Tuber aestivum

Truffle beds are in most part still young and unproductive. The older ones normally bring good yield. *T. aestivum* is often produced in beds made up with plants originally inoculated with *T. melanosporum*.

Tuber borchii

Truffle beds planted in suitable soils are highly productive. It must be noted that *T. aestivum* and *T. borchii*, once believed to be adaptable species and suggested as an alternative for environments not suitable to *T. magnatum* or to *T. melanosporum*, in reality produce truffles only in environments suitable for their own development.

Research projects run at the University of Perugia

The evidence presented above shows that soil and climate conditions suitable for cultivation of valuable species of truffle are now known, but there is only little, incomplete

and often empirical experimental data on truffle-bed cultivation.

In the Department of Plant Biology and Agricultural and Environmental Biotechnology of the University of Perugia, following an agreement with the local government of Regione Umbria, some experimental projects have been started on artificial truffle-beds created by regional public agencies.

In productive beds, projects are aimed at increasing yield through testing application of different levels of irrigation (in terms of quantity of water supplied and irrigation scheduling), different tilling methods and various combinations of tillage and irrigation.

In non-productive beds, which are already ten years old, reasons for lack of production are investigated, with attempts to remove the causes of each failure. Tests include organic fertilization and/or soil nutrient correction, surface tilling, different types of pruning on host plants and inoculation of truffle spores in the soil. There are also artificial truffle-beds which showed production for some years but later ceased producing with no apparent reason. This is a new and serious problem being addressed through investigation of the condition of the truffle-bed (soil, host plant, mycorrhizal status) to establish techniques which could help production recover. In most cases a decrease in the level of mycorrhizae is observed in host plant roots, and basic treatment consists of inoculation with truffle spores, combined with various pruning, tilling, and irrigation activities.

Conclusions

Truffle cultivation in the last thirty years has greatly progressed, establishing itself as a real form of agriculture, sufficiently safe and profitable.

However, there is still a lot to do to step from “sufficient” to completely safe. The weak point of present-day truffle cultivation is the poor understanding of those cultivation techniques for host plants necessary for mycorrhizal conservation in roots and production of carpophores. Research on these topics is long and difficult, but is the only way to provide growers with the good advice on cultivation techniques which they so often request, and which almost as often to date cannot be given. One clear need is the establishment and training of a group of expert agricultural technicians which could support truffle growers in constant link with research centers.

References

- Bencivenga, M. 1982. Alcune metodiche di micorrizzazione di piante forestali con il tartufo nero pregiato di Norcia o di Spoleto (*Tuber melanosporum* Vitt.). – L'Informatore Agrario **38**(21): 21155-21163.
- Bencivenga, M. & Granetti, B. 1990. Valutazione biometrica delle micorrizze di *Ostrya carpinifolia* Scop. prodotte da tartufi di varie specie. – In: Comunità Montana dei Monti Martani e del Serano, Spoleto [ed.]. Atti del II Congresso Internazionale sul Tartufo, Spoleto, 24-27 Novembre 1988. Pp. 141-154. Spoleto.
- Bencivenga, M., Ferrara, A.M., Fontana, A., Granetti, B., Gregori, G., Lo Bue, G., Palenzona, M., Rebaudengo, E., Tocci, A. & Zambonelli, A. 1987. Valutazione dello stato di micorrizzazione in piante tartufigene. Proposta di un metodo. Ministero dell'Agricoltura e delle Foreste, Corpo Forestale dello Stato, Roma.
- Bencivenga, M., Di Massimo, G., Donnini, D. & Tanfulli, M. 1995. Micorrizze inquinanti frequenti nelle piante tartufigene – Nota I – Inquinanti in Vivaio. – Micologia Italiana **24**(2): 185-207.
- Fontana, A. 1967. Sintesi micorrizica tra *Pinus strobus* e *Tuber maculatum*. – Giornale Botanico Italiano **101**: 298-299.
- Fontana, A. & Bonfante-Fasolo, P. 1971. Sintesi micorrizica di *Tuber brumale* Vitt. con *Pinus nigra* Arnold. – Allionia **17**: 15-18.
- Fontana, A. & Giovannetti, G. 1979. Simbiosi micorrizica fra *Cistus incanus* L. ssp. *incanus* e *Tuber melanosporum* Vitt. – Allionia **23**[1978]: 5-11.
- Francolini, F. 1931. Tartuficoltura e rimboschimenti. Federazione italiana dei consorzi agrari. Ed. Piacenza, Piacenza.
- Granetti, B. 1995. Caratteristiche morfologiche, biometriche e strutturali delle micorrizze di *Tuber* di interesse economico. – Micologia Italiana **2**: 101-117.
- Mannozi-Torini, L. 1970. Manuale di tartuficoltura. Edagricole, Bologna.
- Palenzona, M. 1969. Sintesi micorrizica tra *Tuber aestivum*, *T. brumale*, *T. melanosporum* e semenzali di *Corylus avellana*. – Allionia **15**: 121-131.
- Palenzona, M. & Fontana, A. 1979. Synthèse des mycorrhizes de *Tuber magnatum* Pico avec semis de *Quercus pubescens* Willd. – Mushroom Science **10**: 1007-1012.
- Palenzona, M., Chevalier, G. & Fontana, A. 1972. Sintesi micorrizica tra i miceli in coltura di *T. brumale*, *T. melanosporum*, *T. rufum* e semenzali di conifere e latifoglie. – Allionia **18**: 41-52.
- Paolocci, F., Rubini, A., Granetti, B. & Arcioni, S. 1997. Typing *Tuber melanosporum* and Chinese black truffle species by molecular markers. – FEMS Microbiology Letters **153**: 255-260.
- Paolocci, F., Rubini, A., Granetti, B. & Arcioni, S. 1999. Rapid molecular approach for a reliable of *Tuber* spp. ectomycorrhizae. – FEMS Microbiology Ecology **28**: 23-30.
- Rubini, A., Paolocci, F., Granetti, B. & Arcioni, S. 1998. Single step molecular characterization of morphologically similar black truffle species. – FEMS Microbiology Letters **164**: 7-12.
- Rubini, A., Topini, F., Riccioni, C., Paolocci, F. & Arcioni, S. 2004. Isolation and characterization of polymorphic microsatellite loci in white truffle (*Tuber magnatum*). – Molecular Ecology Notes **4**(1): 116-118.
- Venturella, G. 1995. Stato attuale delle conoscenze del genere *Tuber* P. Micheli ex Wiggers in Sicilia. – In: F. Corbetta, G. Pacioni, F. Tammara & L. Marra [eds]. Atti del Convegno “Funghi, Tartufi ed Erbe mangerecce”, L'Aquila, 28 Settembre – 1 Ottobre 1995. Pp. 1-6. L'Aquila.
- Zambonelli, A., Salomoni, S. & Pisi, A. 1993. Caratterizzazione anatomico-morfologica delle micorrizze di *Tuber* spp. su *Quercus pubescens* Willd. – Micologia Italiana **3**: 73-87.