Edible Mycorrhizal Mushrooms in New Zealand — An Update©

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Few of the edible mycorrhizal mushrooms have ever been cultivated and so supplies of most are dependent on those that can be collected from their natural habitats. However, the size of the harvests of many have fallen dramatically over the past century. Also few of the edible mycorrhizal mushrooms of commerce have found their way to the Southern Hemisphere and out-of-season chefs and gourmets must rely on inferior preserved product. There is, therefore, considerable potential for producing these mushrooms in the Southern Hemisphere for the off-season Northern Hemisphere market and, at the same time, helping stem declines in production.

The Périgord black truffle (*Tuber melanosporum*) was introduced into New Zealand in 1985, the first truffière established in 1987 and the first commercial crop produced in 1997. There are now six productive Périgord black truffle truffières between the Bay of Plenty and North Canterbury. The Japanese delicacy shoro (*Rhizopogon rubescens*) and the saffron milk cap (*Lactarius deliciosus*) have also been produced in experimental plantations of specially infected *Pinus radiata.* Experimental plantations have also been established with plants infected with the Burgundy truffle (*T. uncinatum*) and bianchetto white truffle (*T. borchii*) while progress has been made in the development of techniques for cultivating porcini (*Boletus edulis*), matsutake (*Tricholoma matsutake*), and the Italian white truffle (*T. magnatum*).

INTRODUCTION

In the plant world the natural formation of an intimate association between roots and the beneficial mycorrhizal fungi that live in and around them is the norm and the nonmycorrhizal state the exception. All the major forests species that have been looked at and almost all agricultural and horticultural species form mycorrhizal associations, with the notable exception of the Brassicaceae. These mycorrhizal fungi have been found to stimulate the uptake of nutrients, in particular phosphorus, improve water relations, and ameliorate the effects of various pathogens (Smith and Read, 1997). Mycorrhizas, therefore, deserve the attention of both the nurseryman and the grower. However, containerised seedlings raised in soilless media are often nonmycorrhizal at outplanting. It is often assumed that such plants will quickly pick up a suitable mycorrhizal fungus for the particular climate and soil it finds itself in. This does not necessarily occur. For example, it has been known since the 1950s that nonmycorrhizal Douglas fir (*Pseudotsuga menziesii*) in New Zealand can become stunted and chlorotic, particularly when transplanted into areas where Douglas fir has never been grown (Bosselman, 2001; Davis, 1989; Gilmore, 1958; Hall and Garden, 1984).

In addition to their benefit to plant growth, mycorrhizas are also of interest to the chef and the gourmet because many ectomycorrhizal fungi produce edible fruiting

bodies, amongst which are some of the most expensive foods in the world. Examples include the Italian white truffle (*Tuber magnatum*), Périgord black truffle (*T. melanosporum*), and matsutake (*Tricholoma matsutake*) (Hall, 2001; Hall et al., 1998). (Table 1).

Very few of the edible mycorrhizal mushrooms have ever been cultivated and so supplies of most are dependent on those that can be collected from their natural habitats—predominantly woods and forests. However, the size of the harvests of many mycorrhizal mushrooms have catastrophically declined over the past century with suggested causes including deforestation, acid rain, over-picking, and unsuitable management practices in plantation forests (Baker, 1997; Cherfas, 1991; Hall et al., 1998). Data for matsutake production in Japan (Fig. 1) and truffle production in Quercy, France, (Fauconnet and Delher, 1998) clearly illustrate this.

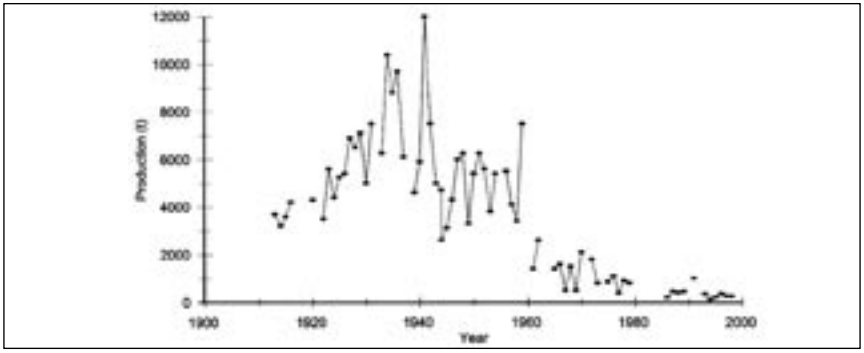

Figure 1. Matsutake production in Japan since 1920. (From Wang et al., 1997).

CULTIVATION OF THE PÉRIGORD BLACK TRUFFLE

The Périgord black truffle was the first of the mycorrhizal mushrooms to be cultivated using a rather rough and ready technique devised by Joseph Talon early in the nineteenth century, a technique well summarised by Singer and Harris (1987). "The indirect culture of the Périgord truffle was undoubtedly invented by a man by the name of Joseph Talon in 1810. Talon was a humble peasant of the "Hameau des Talons", Vaucluse. He planted acorns on a piece of stony siliceous earth, and was suprised to be able to harvest truffles under the young trees, a few years afterwards. An observant and thrifty man, he proceeded to buy worthless land, disseminated there the acorns from his own plantation of 1810 and, keeping his discovery as secret as he knew how, was able to make some profit on the truffles which appeared in his successive oak plantations. When old, father Talon gave away his secret — which by the way had spread at least to his cousin — to a certain truffle merchant and friend of the Talons, by the name of A. Rosseau. It was Rosseau who sent the first lot of cultivated truffles to an exposition in the capital, Paris, in 1855, and turned propagandist for Talon's method of truffle growing."

However, it was not until late in the 1970s that truly scientific methods were devised for the cultivation the Périgord black truffle in artificial plantations. It was about this time that the first author decided that there was considerable potential for cultivating not just the Périgord black truffle in New Zealand but any edible mycorrhizal mushroom that had an international market. The logic behind this was:

- Most of the edible mycorrhizal mushrooms of commerce are restricted to the Northern Hemisphere;
- Few edible mycorrhizal mushrooms have made the accidental journey to the Southern Hemisphere;
- The off-season market was likely to be very large (Table 1);
- Edible mycorrhizal mushrooms are best eaten fresh and deteriorate after preservation so there is a shortage of supply of quality product out-of-season;
- New Zealand has only a handful of native species that form ectomycorrhizas and, despite the introduction of Northern Hemisphere species such as beech, birch, pine, oak, and eucalypt which form ectomycorrhizas, many areas are devoid of ectomycorrhizal fungi that might compete with a desirable introduced edible mycorrhizal mushroom.

Although the primary intention was to produce edible mycorrhizal mushrooms for out-of-season Northern Hemisphere markets there was also the possibility that by growing them in new areas it might also help halt the decline in world production.

Because French and Italian researchers had cultivated the Périgord black truffle in the late 1970s the first author decided to attempt its cultivation first (Hall, 1990; Hall et al., 2001, 1998). The first task was to develop ways of infecting the roots of oak and hazelnut seedlings with the fungus. To do this it was necessary to work from basic principles because there was virtually nothing published in the literature. Even now details of the French and Italian procedures to a large extent are treated as commercial secrets. However, within 2 years the first infected plants had been produced and the first truffières (truffle plantations) established. In their native habitat in France, Italy, and Spain, the Périgord black truffle is typically found in rendzinas and brown earths where the optimum pH is 7.9. The first New Zealand truffières were, therefore, established on the lime-rich soils between Duntroon and Kurow in North Otago (45°S). However, in New Zealand, unlike Europe, there are not large areas of high pH soils in the right climatic zones (Table 2). Consequently, many New Zealand truffières were established on naturally low pH soils where the pH had been adjusted to more than 7.5. This was achieved by applying large quantities of fine and course limestone—typically 2 tonnes of lime ha^{-1} per 0.1 points that the pH had to be raised.

The efforts of the research team were finally rewarded in 1993 when a 5-year-old 0.5-ha truffière near Gisborne (37°S) on the east coast of the North Island produced two small Périgord black truffles. There was then a significant setback when several other mycorrhizal fungi invaded this truffière and appeared to oust the Périgord black truffle fungus. However, a modified management regime was implemented in the truffière, and in 1997, 9 kg of Périgord black truffles were unearthed, the first truffles to be harvested on a commercial scale in the Southern Hemisphere. This truffière produced its maximum yield in 2000 when 65 kg of Périgord black truffles were found with about one-third of these in grade 1. Currently, New Zealand produced grade 1 truffles sell for US$1400 kg-1 with potential returns from truffières on land in suitable localities in excess of US$100,000 per hectare.

Five more truffières also began producing Périgord black truffles during the winters of 2000 and 2001 in the Bay of Plenty, Taumarunui, Paraparaumu, Nelson, and North Canterbury. Of the 11 New Zealand truffières established prior to 1990, seven lie to the north of Christchurch while the remainder are in or south of

Table 1. Market information on some edible mycorrhizal mushrooms.

Scientific name	Common name	Market size (t)	Retail market NZ$ million	Retail price NZ$ per kg (first grade)
Tricholoma matsutake	matsutake	4000	1000	750 – 2500
Lactarius deliciosus	saffron milk cap	> 1000	50 – 100	30 – 60
Boletus edulis	porcini	> 12,500	500	30 – 300*
Rhizopogon rubescens	shoro	?	?	1000 …
Tuber magnatum	Italian white truffle	> 50	350	3000 – 35,000
T. melanosporum	Périgord black truffle	> 50	350	1000 – 3500*
T. uncinatum	Burgundy truffle	> 50	100?	200 – 800
T. borchii	bianchetto truffle	> 50	100?	200 – 800

* The higher figures are off-season prices.
… Yusho Nakamoto, pers. comm., Juken Sangyo Co. Ltd., Hiroshima, Japan.

Table 2. Climatic conditions in the Périgord black truffle-growing areas of France and Italy and areas adjacent to where Périgord black truffles are currently being produced in New Zealand.

	Range in						
	France and Italy	Opotiki	Gisborne	Taumarunui	Paraparaumu	Nelson	Waipara
Latitude (°)	41 - 47	38	39	39	41	41	43
Annual rainfall (mm)	600 - 1200	1400	1058	1443	1054	986	729
Accumulated degree days (>10°C)	900 - 1900	1493	1430	1292	1167	1038	1049
Mean daily temperature in summer (July in Northern Hemisphere,	(16.5°C) 17.5 - 22°C	18.5	18.3	18.3	17.1	17.2	17.5
January in Southern Hemisphere) Mean daily temperature in winter1	1-8°C	9.2	9.0	7.9	8.3	6.5	6.5
(January in Northern Hemisphere, July in Southern Hemisphere) Annual sunshine hours	1900 - 2800	2169	2172	1704	2043	2397	1999*
"Summer" sunshine hours (April to September in Northern Hemisphere, October to March in Southern Hemisphere)	1200 - 1800	1227	1283	1079	1227	1377	1175*

* Christchurch

Note: The climatic requirements of the black truffle are not fully understood and the figures above are only indicative of conditions in suitable areas in New Zealand and the black truffle growing regions of Europe. Many areas of New Zealand with the same latitude as the truffle growing regions of France have, for example, lower sunshine hours than France and Italy and are cooler in summer but warmer in winter.

Christchurch. All six of the productive truffières are north of Christchurch (Table 2). Currently the New Zealand Truffle Association is funding research that seeks to determine factors that influence fruiting of the Périgord black truffle in New Zealand and whether it is possible to trigger fruiting, for example, in the more southern truffières.

OTHER EDIBLE MYCORRHIZAL MUSHROOMS

In 1990 Professor Wang Yun joined the edible mushroom team at Invermay Agricultural Centre, Mosgiel, with the specific intention of finding ways of cultivating the Japanese delicacy, matsutake (Wang et al., 1997). However, it was not long before the team expanded their research to include the possibility of growing edible mycorrhizal mushrooms as secondary crops in New Zealand's *P. radiata* plantations, for example, the Japanese delicacy shoro (*Rhizopogon rubescens*), saffron milk cap (*Lactarius deliciosus*), and porcini (*Boletus edulis*) (Hall and Wang, 2000). In 2001 the first shoro fruiting bodies were harvested in Nelson, only 21 months after inoculated radiata pine were planted and, very recently, the first saffron milk cap was harvested from inoculated pines in North Otago. Considerable advances have also been made in the cultivation, not only of matsutake, but also bianchetto white truffle (*Tuber borchii* = *T. albidum*), Burgundy truffle (*T. uncinatum* = *T. aestivum*) and Italian white truffle (*T. magnatum*).

Further information on mycorrhizas and the edible mycorrhizal mushrooms being researched by Crop & Food Research's edible fungi group can be found on the web at <www.crop.cri.nz/psp/em-mushrooms>.

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