

TRUFFLE FARMING GUIDE

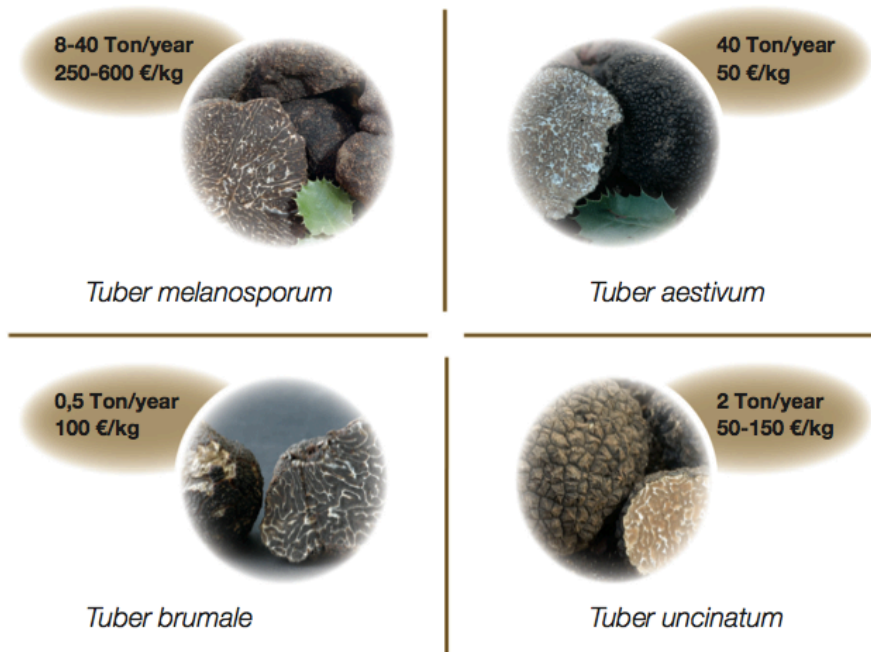


This is a short booklet with graphics from the Book *Truffle Farming Today. A Comprehensive World Guide*. 2015. Marcos Morcillo, Mónica Sánchez, Xavier Vilanova. ISBN 978-84-617-1307-3

Truffles are the fruit of a mycorrhizal fungi. That means that lives associated to the roots of some host trees or shrubs, as oaks, holm oaks and hazels, Cistus or some pines. Truffles fruits into the ground and some species become aromatic with the aim that some animals dig them up the ground and while eating them spread their spores. The aroma is also appreciated by humans and recognized by dogs that can be trained to harvest them.

Truffles belong to the genus *Tuber*, into de Ascomicotina. There are several species, around 40, but a few of them have a real market value, like the black truffle or Perigord truffle *Tuber melanosporum*, the winter truffle *Tuber brumale*, the summer truffle *Tuber aestivum* and its ecotype the burgundy truffle *Tuber uncinatum*, and the white truffle from Piamonte *Tuber magnatum*, with great value, but its cultivation still has random results.

- Black truffle (*Tuber melanosporum* Vitt)
- Winter truffle (*Tuber brumale*)
- Summer truffle (*Tuber aestivum*)
- Burgundi truffle (*Tuber uncinatum*)



Annual volumes gathered and prices paid at source for the main truffles marketed in Spain.

ECOLOGY OF TRUFFIERES: GEOGRAPHIC, GEOLOGICAL AND TOPOGRAPHIC CHARACTERISTICS

La trufa negra se desarrolla sobre suelo calizo, en carrascales, quejigares y coscojares de la región Mediterránea de España. Éstas son mayoritarias en la mitad oriental de la Península y se encuentran sobre rocas de edad geológica encuadradas en los periodos Primario, Secundario-Mesozoico (Triásico, Jurásico, Cretácico), Terciario y aluviales del Cuaternario o recientes, con un predominio de calizas duras del Jurásico Superior. Las trufas aparecen de forma natural a altitudes entre 100 y 1500 m.s.n.m. y en exposiciones soleadas. Es conveniente elegir zonas con una ligera pendiente para evitar el encharcamiento de los terrenos llanos y los fondos de valle (a no ser que presenten un subsuelo con buen drenaje), así como la erosión de los terrenos muy inclinados, donde además será más compleja la mecanización y se favorece la desecación del suelo.



Soil map of Europe, with light grey showing the distribution of the leptosol soil type. This is the most common soil type in the truffle areas of Spain and southern France, along with calcisol, which is shown in yellow. Source: Soil Atlas of Europe, European Soil Bureau Network, European Commission, 2005.

BLACK TRUFFLE SOIL CHARACTERISTICS

Most of parameters before analyzed for truffle culture are not bearing in mind nowadays. Texture, carbonates, iron, magnesium, potassium...have great variability. Actually the soil structure trough the study of the horizons and the biological activity are more studied.

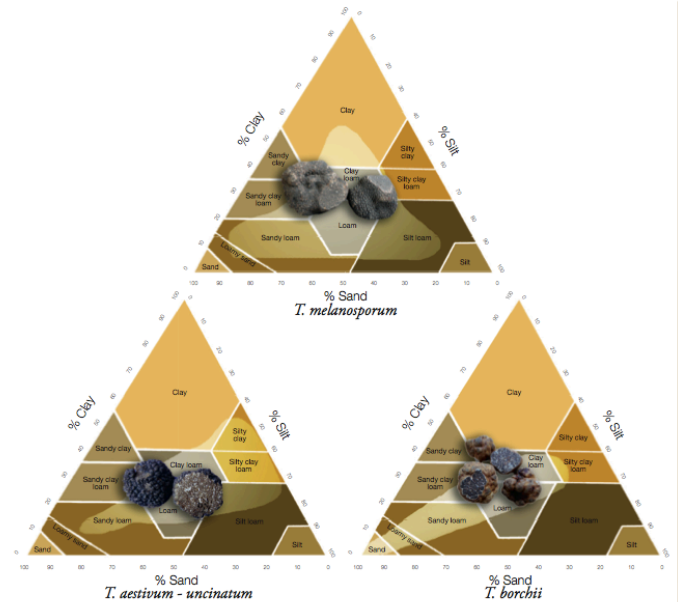
So to know if we can grow truffles on a soil we should study the horizons, confirm the presence of carbonates and analyze the pH (that should be between 7.5-8.5)

Soil should not be water Proof, allowing water and air to drain trough.

To check if the soil has carbonates we can just drop diluted clorhidric acid and see that the soil boils (effervescence).



The pH ranges for fruiting of the three truffle varieties are relatively wide, but the optimum range for all of them is similar, i.e. between 7.5 and 8.

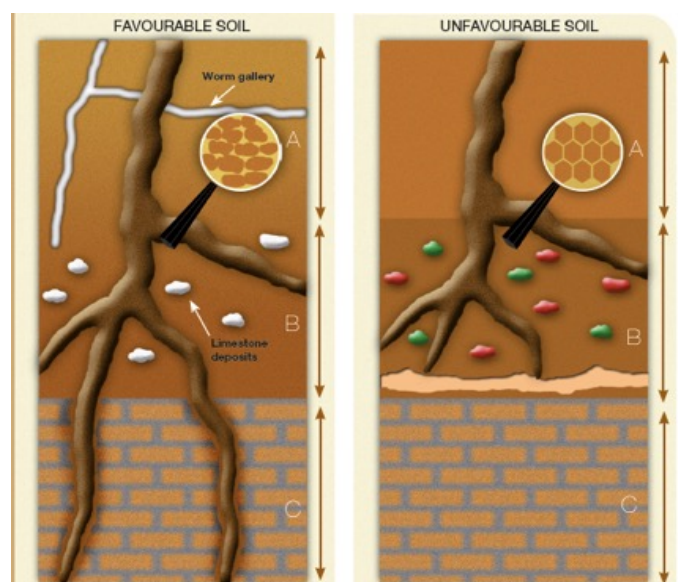


The area marked in each triangle refers to the soil textures in which each truffle variety is found naturally. However, in truffle farms there should be no more than 30% clay for the black truffle and sandier textures must be found for the bianchetto truffle.

Soil profile

Should not have discontinuities between layers, with some difficult to mark limits between them.

Crumble structure and spherical particles. Avoid prismatic structures, sign of lixiviation. Laminar structures shows compactation and flood. Bad soil structures get grooved and heavy on dry weather.



Tables comparing the characteristics of soils that are favourable and unfavourable for truffle production. The favourable column lists some of the characteristics that indicate good drainage and aeration. This data provides very useful information for subsequent working of the plantation.

BLACK TRUFFLE CLIMATE

Black and summer truffle are adapted to dry and hot conditions, with well marked seasons, humid temperate or cold sub humid Mediterranean climate. Hot and humid springs, dry summers with some storms, no frost at the beginning of autumn, and winters with no long cold periods below 10°C.

Rain between 425-900 mm. (600-1500 mm in Italy and France). 48-64 mm of rain monthly from June to the end of august, from a few summer storms.

	Temperature °C
Annual average	8.6 – 14.8
Average hottest month	16.5 – 23.5
Average coldest month	1 – 8.2
Absolute maximum	35 – 42
Absolute minimum	–9 – –25
Optimal temperature ranges for the growth of black truffles are once again variable. The temperatures in their geographic area of distribution are shown here. ⁶⁷	

Previous crops

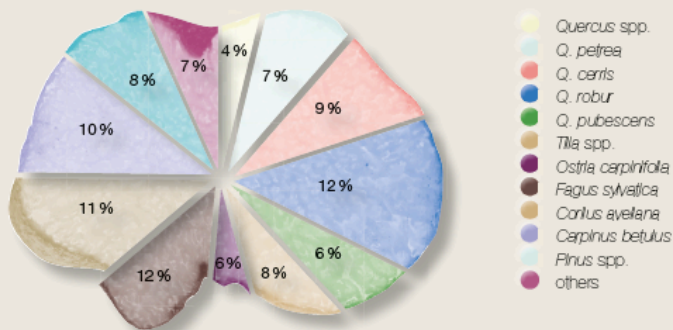
Previous crops will condition the organic matter contents and fungi contaminations on the area we're planning to plant the mycorrhized seedlings.

Best previous crops are cereals, pulses, lucerne, most of fruit trees, as they are endomycorrhizal.

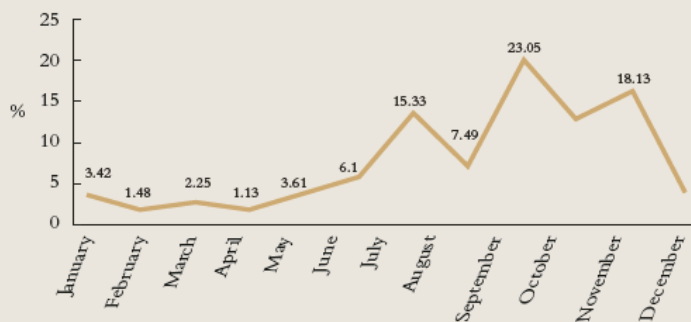
HOST PLANTS ELECTION

Truffles grow in symbiosis with a wide variety of plants (see next chart). But just some of them are used for its cultivation. Actually in Spain about 90% of black truffle plantation are with holm oak (*Quercus ilex ssp. ballota*), and secondary oaks (*Quercus pubescens*, *Quercus faginea*) and hazel (*Corylus avellana*).

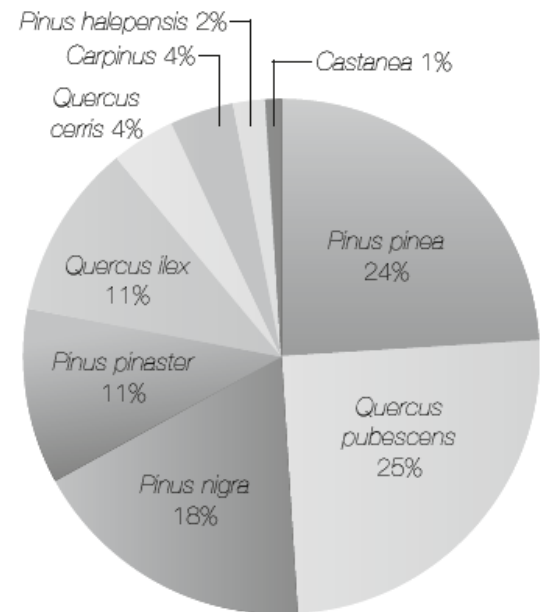
Main host trees for the black truffle	
Trees used for growing <i>Tuber melanosporum</i>	Secondary species where <i>T. melanosporum</i> can be cultivated or it has been found in the wild
Holm oak (<i>Quercus ilex ssp. ilex</i> , <i>Q. ilex ssp. ballota</i>) Oaks (<i>Quercus pubescens</i> , <i>Q. cerrioides</i> , <i>Q. petraea</i> , <i>Q. Robur</i> , <i>Q. faginea</i>) Kermes oak (<i>Q. coccifera</i>) Hazel (<i>Corylus avellana</i>)	Pines (<i>Pinus nigra</i> , <i>P. sylvestris</i>) Turkish hazel (<i>Corylus colurna</i>) Birch (<i>Betula pendula</i>) Hornbeam (<i>Ostrya carpinifolia</i>) Linden (<i>Tilia</i>) Corck oak (<i>Quercus suber</i>) Poplar (<i>Populus</i>) Willow (<i>Salix</i>) Beech (<i>Fagus sylvatica</i>) Chestnut (<i>Castanea sativa</i>) Cedar (<i>Cedrus</i>) Rockrose (<i>Cistus albidus</i> , <i>C. incanus</i> , <i>C. laurifolius</i>)



Frequency of host trees where *Tuber aestivum* fruits in central Europe.³¹



Frequency of months when *Tuber aestivum* fruits in central Europe.³¹



Frequency of host trees for *bianchetto* in Tuscany (Italy) ³³.

Main host trees for the summer truffle

Main host trees for <i>aestivum</i> type in Spain	Main host trees for <i>uncinatum</i> type	Secondary species where <i>T. aestivum</i> can be cultivated or it has been found in the wild
Pines (<i>Pinus nigra</i> , <i>P. sylvestris</i>) Holm oak (<i>Quercus ilex</i>) Oak (<i>Quercus faginea</i>)	Hazel (<i>Corylus avellana</i>) Beech (<i>Fagus sylvatica</i>) Oak (<i>Quercus robur</i> , <i>Q. cerris</i>) Linden (<i>Tilia cordata</i>)	Chestnut (<i>Castanea sativa</i>) Oaks (<i>Quercus coccifera</i> , <i>Q. pedunculata</i> , <i>Q. petraea</i> , <i>Q. pubescens</i> , <i>Q. sessiliflora</i>) Turkish hazel (<i>Corylus colurna</i>) Hornbeam (<i>Carpinus betulus</i> , <i>Ostrya carpinifolia</i>) Pines (<i>Pinus halepensis</i> , <i>P. pinea</i> , <i>P. Strobus</i>) Fir (<i>Picea abies</i>) Cedar (<i>Cedrus atlantica</i>) Pecan tree (<i>Carya illinoensis</i>) Rockroses (<i>Cistus laurifolius</i> , <i>C. incanus</i>)

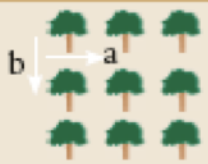
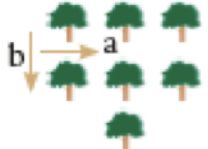
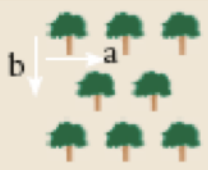
Main host trees for bianchetto

Main host trees for growing bianchetto or naturally gathered (by frequency)	Secondary species where <i>T. borchii</i> can be cultivated or it has been found in the wild
Oak (<i>Quercus pubescens</i>) Stone pine (<i>Pinus pinea</i>) Black pine (<i>Pinus nigra</i>) Maritime pine (<i>Pinus pinaster</i>) Holm oak (<i>Quercus ilex</i>)	Poplar (<i>Populus nigra</i>) Oaks (<i>Quercus cerris</i> , <i>Q. robur</i>) Hornbeam (<i>Ostrya carpinifolia</i>) Aleppo pine (<i>Pinus halepensis</i>) Cork oak (<i>Quercus suber</i>)

LAYOUTS AND TREE DENSITY

We recommend densities between 200-400 trees/Ha for the black truffle. Less density as deeper, rich soils and with water stocks, as trees will grow faster. More trees per hectare allow more trees to fruit and less time to wait for the production to start, but we have to prune more to avoid the plantation to get closed.

Usually plants are located at 6x6 or 7x7 but we can also join plants in the row and separate the rows at more distance (6x8, 5x7 or 4x10). In this case rows are planted north to south, allowing sun to light the centre of the whole row.

Planting densities depending on layout			
Regular pattern		$a=b$	Number trees/Ha $\frac{10.000}{a^2}$
In rows		$a \neq b$	$\frac{10.000}{a \times b}$
Hexagonally		Rows moved half distance $a/2$	$\frac{10.000}{0,866 \times a^2}$
Planting densities depending on layout.			

LAND PREPARATION AND PLANTING

Previous works to get the soil ready to plant are done in summer and autumn. Any ploughing will be done with no heavy tractors and on dry soil avoiding soil compaction.

If soil is OK, but there's no drainage we can plough deeper trying to break the plough layer that appear after several years working at the same deep. Note not to tumble and mix soil layers, that can lead to a delay starting to fruit.

Between November and may dig the plant holes and mark them not to harm the small seedlings once planted, hard to see trough the weeds.

In the following figure you can see the most comon tasks and machinery used to prepare the soil for planting a truffiere.



Subsoiler or ripper to break up the plough pan. 2-6 months before planting.



Mouldboard ploughing. After subsoiling, a disc harrow is generally used, but when vines were previously cultivated, or if there are remnants of stumps and roots, mouldboard ploughing is recommended to leave the ground clean, even though this turns over the soil horizons. 2-6 months before planting.



Although stoniness is beneficial in truffle farming, it may be worthwhile to break up the stone to make gravel. This will give the truffles a better shape (spherical without deformations), and avoids dogs hurting their paws when hunting them (in the case of stones with sharp edges). 2-6 months before planting.



Rotary tiller or milling machine to loosen the soil just before planting.



Mechanised planting using a planting machine with GPS



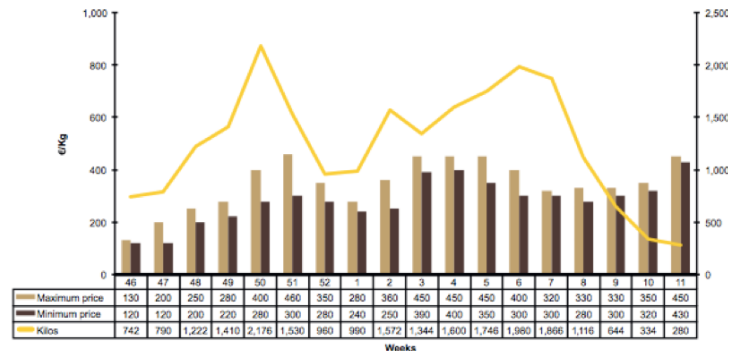
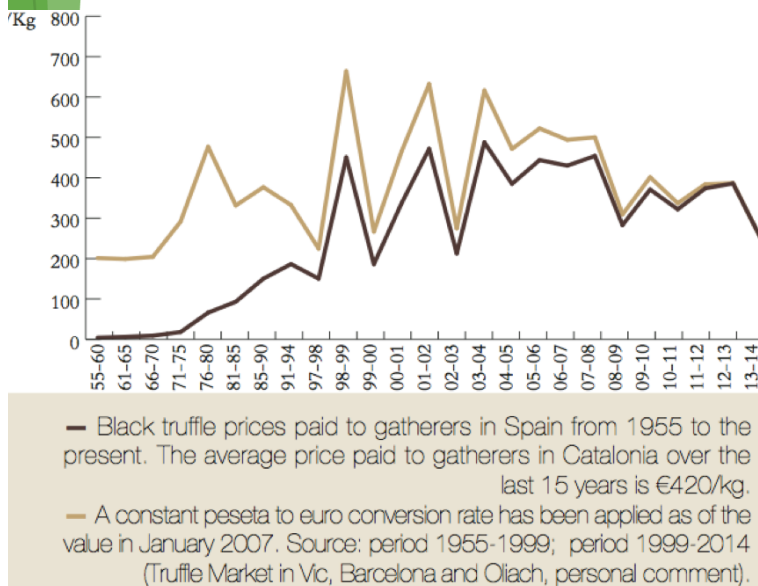
In some plantations the rows are covered with geotextile. In areas with hot summers a double layer is recommended, black underneath and white on top.

ECONOMICAL FEATURES ABOUT TRUFFLE GROWING

The black truffle and summer truffle growing areas have limestone soils, generally of a poor quality. These areas are used for crops associated with low agricultural performance. These farms depend on financial aid for their survival. Truffle growers do not have to depend on subsidies any more, as they can triple the income earned from traditional crops in these areas, and the value of farming land may even increase in truffle growing regions.

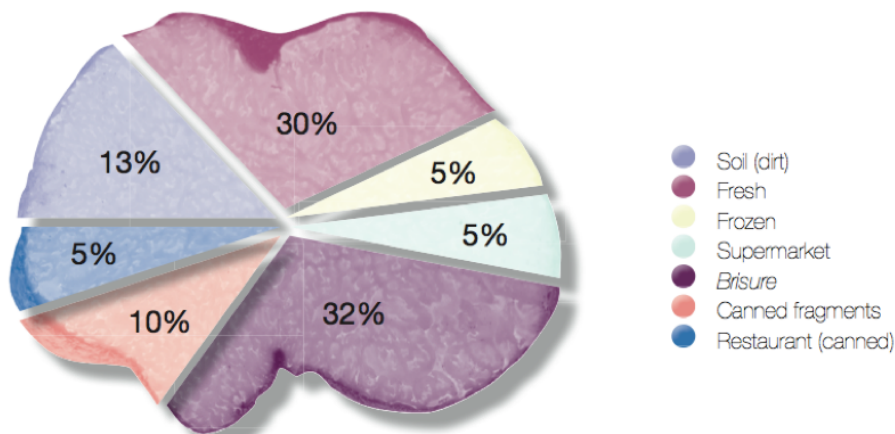
Spain, where it is estimated that some 10,000 families are involved in truffle growing and truffle gathering, accounts for 30-50% of world black truffle production. Very few people now work exclusively as truffle hunters. Most combine truffle hunting with other work and/or do it at the weekend, or try to match their holidays with the gathering season. A truffle hunter working a full day currently collects between 3-5 kg of wild black truffle a week, very far from the 8-12 kg a day remembered by old truffle hunters.

The price of black truffles in Spain varies greatly depending on whether the season is good (with plenty of truffles) or not. Truffle prices conform to traditional models, where higher production means lower prices. Truffle gatherers are paid between €200 and €850 per kg for the black truffle, 197 and, generally, just under half this amount for winter truffles in the same season. The price paid to gatherers for the summer truffle in Spain is between €35 and €80 per kg.



Truffle volumes and weekly prices in the 2013-14 season in the Vaucluse region of south east France, where the most important markets Carpentras and Richerenches, are found. The latter accounts for 57% the volume of truffle trade in France.

Source: Syndicat des Trufficulteurs de Vaucluse



Profitability of truffle farming

It is hard to ascertain the average production of artificial plantations. There are references to a single burn being able to produce 10 kg of truffles and to a plantation of oaks mycorrhized with black truffle producing 200 kg/ha/yr. In contrast, some plantations have never started to produce, for a variety of reasons, so truffle farming as a business is not without risk. In Spain, a minimum production of 8-10 kg/ha/yr is required to recoup the investment made in a plantation. In other countries, with high initial costs, such as liming to bring up the pH, more truffles have to be produced before any profit is made, or, to put it another way, the cost of production per kilogram of truffle is greater. Some French truffle growers have remarked that production begins to decrease after 50 years. However, we have found several truffle fields over a hundred years old with burns over 12 m in diameter and in full production. Current net values in plantations in Spain, France and Italy range from €19,424/ha to €66,972/ha. The average internal rate of return is always above 9% and the payback period of the investment is equal to or greater than 10 years.

The following table have costs and just prices for black truffle farming in Spain:

Year	Works	Cost €/ha	Maintenance €/ha	Production Kg/ha	Truffle €/ha	Cash Flow	Balance
0	Plantation	-1.800				-1,800	-1800
1			-300			-300	-2100
2			-300			-300	-2400
3			-300			-300	-2700
4			-300			-300	-3000
5			-300			-300	-3300
6			-300			-300	-3600
7			-300			-300	-3900
8			-300			-300	-4200
9			-300			-300	-4500
10	Fencing Irrigation	-1500 -1500	-300			-1800	-6300
11			-300	8	2400	2100	-4200
12			-300	10	3000	2700	-1500
13			-300	12	3600	3300	1800
14			-300	13	3900	3600	5400
15			-300	15	4500	4200	9600
16			-300	16	4800	4500	14100
17			-300	17	5100	4800	18900
18			-300	18	5400	5100	24000
19			-300	19	5700	5400	29400
20			-300	20	6000	5700	35100

Financial study of a one hectare black truffle plantation in Spain.