Truffles and Mushrooms

(Consulting Ltd)

Effect of fertilisers in truffières

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1 *Early work on the effect of fertilisers on truffles*

Fertilisers have been used to fertilise truffières as far back as the 1970s in the hope of encouraging growth of the truffle fungus. French examples include Fructitfuf (Pebeyre et al. 1985), Lombrisol, Phaligal and Vegethumus. The effect of these was well summarised by Bradshaw in his PhD thesis (2005):

> "Fertiliser application is not often recommended in commercial truffières in France and elsewhere in Europe as varied results have been observed (G. Chevalier pers. comm.). Furthermore, the composition of fertilisers that have been used in France, for example, is often not available with the exception to acknowledge their organic or inorganic status. Four products that have been examined experimentally include Fructitruf (1150 kg ha^{-1}, 6 % organic N, rich in K & Mg), Phaligal (530 kg ha^{-1}, organic, composition unknown), Vegethumus (530 kg ha^{-1}, composted sheep manure) and Lombrisol (530 kg ha^{-1}, worm castings/compost) (Verlhac et al. 1989). The application of these products to a producing truffière (established in 1972) was examined over four seasons and results were variable. In each case, fertiliser application reduced the number and weight of truffles from producing trees. This was most notable in those trees that were treated with Fructitruf. The number of producing trees increased slightly when treated with Vegethumus and Lombrisol but this may have been an artefact of truffière age as all treatments (including the unfertilised control) showed an increase in the number of producing trees over the experimental period (Verlhac et al. 1989). Ongoing results of this and other similar experiments are not documented and similarly, experiments utilizing inorganic fertilisers are lacking in the literature. In New Zealand and Tasmania, the effect of fertiliser application has not been published in any form with the exception of a glasshouse trial by Brown (1998). This study found the levels of infection of *T. melanosporum* were maintained at applied P [phosphorus] rates as high as 150 mg kg^{-l} soil (-250 kg P ha-1) and the point was argued that P application could be used to limit the development of native Australian ECM fungi given their low tolerance to elevated soil P. The P-fixing ability of the soil used in the experiment (a grey sandy loam) was not reported. There was no determination of the impact of applied P on ascocarp production of *T. melanosporum* in the field."

Gerard Chevalier (1998) was more direct:

> The fertilization must be carried out according to soil analysis. The truffle growers can use mineral and/or organic fertilizers (Chevalier and Poitou, 1990). The only organic fertilizer used is the Fructitruf. The opinions about this product differ very much (Olivier et al., 1996). Anyway it is sure that it is better not to fertilize than fertilize badly. An unsuitable fertilization can sterilize a truffière.

Perhaps the most telling observation about soil nutrients and truffle production comes from a tiny truffière planted in 1988 in New Zealand. The soil has an Olsen extractable phosphorus concentration of just 2 (extremely low) and a carbon/nitrogen ratio of 13 (i.e. deficient in nitrogen), but in 2014 produced nearly a kilogram of truffles per tree. Similarly, there is a general observation by many owners of truffières that the most scrawny, poor growing tree in a truffière, which appears to be struggling to survive, is the one that produces the most truffles.

2 More recent studies

Apart from the early research there is a comparative lack of published agronomic studies over the past two decades compared to the vast amount of work on truffle molecular topics. The reasons for this are obvious: molecular studies go into prestigious journals, gain more impact factors and citations, and can often be completed in months rather than years or decades. In contrast, meaningful field experimentation takes years to complete and may remain unpublished if a company, such as the Wine and Truffle Company in Western Australia, perceives that the novel information might give them a market edge. Despite this there has been some data published. For example, Suz et al. (2010) found that when a high P fertilizer was applied to foliage, *T. melanosporum* root colonization increased, whereas when the same fertilizer was applied to the soil, indigenous competitive fungi were enhanced at the expense of *T. melanosporum*.

A number of inorganic and organic compounds have been applied to truffières in New Zealand over the past 30 years. Often these have been judicious applications of trace elements to correct severe falls in their concentrations following liming. Nitrogen in the form of calcium ammonium nitrate has also been applied in very small quantities to aid newly planted trees to get established. However, there have been other organic mixtures applied which seem to have little or no grounds for use. We are aware of two previously productive truffières, one in the North Island and the other in the South Island where application of "fertilisers" stopped production. Clearly its use was misguided.

3 Effect of phosphorus and nitrogen on non-truffle ectomycorrhizal fungi

Truffle fungi form ectomycorrhizas (EM) with their host plants. Consequently, it is logical to consider the results of experiments where fertilisers have been applied to non-truffle mycorrhizal fungi. In many of these a lack of phosphorus in the soil encourages the growth of mycorrhizal fungi (Wallander & Nylund 1992) while the application of P or nitrogen (N) can markedly reduce mycorrhizal formation (Smith & Read 2008). For example, EM fungal communities respond to increased N with decreased production and diversity of fruiting bodies aboveground and radical shifts in the species composition of EM fungi colonizing roots belowground (Avis et al. 2003; Avis & Charvat 2005; Lilleskov & Bruns 2001; Lilleskov et al. 2001, 2002; Peter et al. 2001; Taylor et al. 2000). Furthermore, in a meta-analysis across 51 published mycorrhizal studies, it was determined that mycorrhizal abundance decreased 15% when plants were fertilised with nitrogen and 32% with phosphorus fertilisation (Treseder 2004).

Despite the perceived overarching detrimental effects N and P are perceived to have on EM fungi, it must be noted that in some studies the application of nitrogen does not always depress mycorrhizal formation. For example, Meghan et al. (2009) concluded in their experiments:

> "Organic and inorganic N additions differed in their effects on total ectomycorrhizal root tip abundance across hosts, and these effects differed for individual morphotypes between oak and pine seedlings. Mycorrhizal root tip abundance across hosts was 90% higher on seedlings receiving organic N compared to seedlings in the control treatment, while abundances were similar among seedlings receiving the inorganic N treatments and seedlings in the control. On oak, 33-83% of the most common morphotypes exhibited increased root tip abundances in response to the three forms of N, relative to the control. On pine, 33-66 % of the most-common morphotypes

exhibited decreased root tip abundance in response to inorganic N, while responses to organic N were mixed."

Such findings are important but it must be pointed out that Meghan et al.'s study was on seedlings housed in pots in a greenhouse, the experiment only lasted 10 weeks, and nitrogen was applied at 35 kg ha^{-1} – a very low rate!

4 *Conclusions*

We are not convinced that N and P fertilisers, and organic products that supply significant quantities of these elements are likely to have beneficial effects on truffle ectomycorrhizal formation. Consequently, we warn against the use of such products in truffle farming unless the proprietors of such products can provide *sound scientific and statistical data* that supports their product. Only rarely does farmer testimony meet these criteria.

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