Truffles and Mushrooms

(Consulting Ltd)

Use of glyphosate and other herbicides in truffières

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Contents

1 Introduction

At the outset I must confess to being overly cautious about the use of chemicals in agriculture - I simply don't trust them. My first wife, a farmer's daughter, took a dozen years to die from Multiple Systems Atrophy, one of the synuclein diseases that have been linked to agriculture. So I address the issue of the use of herbicides in truffle cultivation with some caution. The safety of glyphosate in agriculture was also reviewed by the New Zealand Environmental Protection Authority in August 2016 and concluded that if used according to instructions concluded that "glyphosate is unlikely to be genotoxic or carcinogenic to humans, and does not require classification under HSNO as a carcinogen or mutagen" (EPA 2016 http://www.epa.govt.nz/publications-resources/bulletin/bulletin/Pages/Glyphosate-in-New-Zealand.aspx).

2 Glyphosate usage in truffières

One valiant couple in the Hawkes Bay region of New Zealand vowed to make their truffière totally organic. So for several years after establishment they carefully hand weeded around their trees. However, the couch grass (twitch, *Elymus repens* = *Agropyron*) *repens*), which spreads by rhizomes and can regrow from even the smallest piece left behind in the soil, eventually got the better of them. So like many truffle growers in Europe and the Southern Hemisphere they switched to using the herbicide glyphosate (e.g. Roundup). This is a systemic herbicide that is readily absorbed by leaves and stems and translocated throughout the plant. In the establishment years of his truffière, Alan Hall also used glyphosate but at an application rate about one third of normal and found that this triggered formation of the brûlé.

The use of herbicides soon after planting can also increase plant survival as illustrated by the field work of Bonet et al. (2006): "Glyphosate weed control improved seedling survival by up to 16% over control seedlings without jeopardizing truffle mycorrhizae in the first year". Similarly, in Olivera et al's field study (2011) on the effects of fertilisers and herbicides in Périgord black truffle truffières, they concluded:

> "The low dose of irrigation (50% of the estimated water deficit for the site) and glyphosate weed control both increased total root tips/plant and *T. melanosporum* colonized tips (ectomycorrhizae) by approximately two-fold, compared to control treatments."

Glyphosate and other herbicides might be applied with a backpack sprayer, or motorized units mounted on a tractor or four-wheeled farm vehicle (Hall et al. 2007). Like any pesticide, and regardless of its perceived safety, it is always best to treat the chemical to be an order of magnitude more dangerous than the label might suggest. In young truffières, the use of rigid tree protectors enables herbicides to be sprayed quite close to the trees, leaving only a few weeds inside the guards to be removed by hand.

3 *Effect of glyphosate on pure cultures of mycorrhizal fungi*

Whether glyphosate has any direct effects on mycorrhizal fungi has also been investigated in a number of research papers where mycorrhizal fungi were grown in pure culture in laboratories. This is hardly the real world but it was probably all that some researchers could afford to do with the funds available. Below are some extracts from these papers:

Chakravarty & Sidhu 2007 [ectomycorrhizal fungi]

In vitro growth tests with glyphosate (RoundupR), hexazinone (liquid Velpar L.R and granular Pronone™5GR) and trichlopyr (GarlonR) on five species of ectomycorrhizal fungi (*Hebeloma crustuliniforme, Laccaria laccata, Thelophora amcrieana, T. terrestris* and *Suillus tomentosus*) showed varied species sensitivity to different concentrations of herbicides. Fungal growth was significantly (P = 0.05) reduced particularly at concentrations above 10 ppm. Garlon with trieolopyr as a.i. was the most toxic of the four herbicide formulations.

Estoc et al. 1989

Data to come.

Laatikainen & Heinonen-Tanski 2002 [ectomycorrhizal fungi]

……The fungicides, chlorothalonil and propiconazole, had the clearest inhibitory effect on growth of mycorrhizal fungi. Conversely, maneb, glyphosate and terbuthylazine stimulated the growth of some mycorrhizal fungi……

Pasaribu et al. 2013 [arbuscular mycorrhizal fungi]

..... Alachlor (1.8, 3.6 and 5.4 µg a.i. g-1 dry soil) and glyphosate (1.08, 2.16 and 3.24 µg a.i. g-1 dry soil) were applied to mycorrhizal and nonmycorrhizal plants as soil drench. Peanut plant growth was significantly enhanced by the *G. mosseae* inoculation, but with the increasing application rates of alachlor the growth was significantly reduced at all levels, in contrast, the growth was unaffected by glyphosate treatments. The P concentration in shoot and P inflow into roots was significantly increased in mycorrhizal plants. Whereas, both P concentration and inflow were significantly decreased with the increasing rates of alachlor, but significantly increased with the application rates of glyphosate, with the highest value (0.333%, and 65.31 x 10-13 mol P m-1 s-1 P concentration and inflow, respectively) obtained at recommended glyphosate field rate (2.16 µg a.i. g-1).....

Beyrle et al. 2011 [orchid mycorrhizas]

Effects of nitrogen nutrition and application of glyphosate (as Roundup™) on the interactions between protocorms of *Orchis morio* and a mycorrhizal *Rhizoctonia* species were investigated…..in liquid culture…… Application of glyphosate at 0.5 or 1.0 mM had no effect on fungal growth and at 1.0 mM did not cause death of asymbiotic protocorms, but resulted in failure of mycorrhizal initiation.

Monsanto (2011), a supplier of glyphosate, concluded “The exact design of studies looking for glyphosate effects on microbial communities is very important. Although some laboratory tests have shown effects on……soil fungi, effects are typically observed only under artificial laboratory conditions and at glyphosate concentrations well above normal field application rates. This has

caused several researchers to conclude that it is difficult to extrapolate results from the laboratory to the natural soil environment. In this instance on the basis of data presented here and in Trappe et al.'s 1984 review "Reactions of mycorrhizal fungi and mycorrhiza formation to pesticides" I am inclined to agree with Monsanto and that glyphosate is unlikely cause major problems in truffle cultivation. Similarly, on the basis of the data presented here comments on some web sites that RoundUp should not be used are unjustified.

4 Mowing, herbicides and indirect effects

In many parts of the world, New Zealand included, Périgord black truffles (*Tuber melanosporum*) are now being cultivated where the rainfall is considerably higher than where it grows naturally in France, Italy, and Spain. In these wetter areas it might be expected that there will be more weed growth between the trees that will need to be controlled using either herbicides or machinery. If the dead material following the use of herbicides or machinery is then left in situ, there is the potential for the material to rot and acidic percolates to run through the soil dropping the pH. This could allow competing mycorrhizal fungi getting a foothold within a truffière.

The organic residues might also act as a blanket minimizing fluctuations in soil temperature that are normal in natural brûlés and which have been suggested as being likely triggers to fruiting (Hall et al. 1998, 2002a, 2007). The blanketing effect will also drop peak soil temperature considerably, that would be a problem in areas that are climatically marginal for truffle cultivation.

Because repeated use of glyphosate selects against grasses in favour of dicotyledons, Sourzat (2002) warned against overuse of this herbicide. Instead, he suggested working the ground in spring, when it will not have any detrimental effects on truffle production, and then controlling weeds by mowing. However, it would certainly be unwise to aerate the ground or even mow the grass when fully developed immature truffles may be present just under the soil surface – as early as late February in New Zealand (the equivalent of late August in the Northern Hemisphere) – a suggestion that seems to have been advanced by the New Zealand Truffle Association after its AGM in August 2015.

5 Alternative herbicides

An alternative to glyphosate is the non-systemic desiccant herbicide glufosinate-ammonium (KCL Commercial 2015 [1]). Glyphosate can be used to control difficult grasses such as couch (or creeping twitch, *Agropyron repens*), although three or four applications may be needed during a season to finally bring it under control. Glufosinate-ammonium (Buster, KCL Commercial 2015) can also be sprayed onto hazelnuts with a woody trunk to kill suckers. It is also effective in controlling stoloniferous clovers and other legumes that can completely colonize brûlés after the use of glyphosate (KCL Commercial 2015) (Figure 1).

Figure 1. Areas around plants sprayed with glyphosate can be quickly colonised by clovers and other legumes.

[1] Note that desiccant herbicides containing a mixture of 2,4-D and dichlorprop do not contain glufosinate-ammonium and should not be used (Brush Buster – Chemindustry.com; Outside Pride 2008)

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