The Commercial Application of *Trichoderma* (Beneficial Fungi) in New Zealand Horticulture

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INTRODUCTION

The *Trichoderma* species is one of a small group of beneficial fungi being successfully utilised on a commercial scale for biological control of other fungi. This microorganism has now been registered as a biofungicide in many countries including France, U.K., Belgium, Switzerland, Sweden, Chile, New Zealand (N.Z.), and U.S.A. In its natural environment *Trichoderma* is a resident of the litter and woody plant debris in humus or associated with plant matter in the soil. It acts as a mycoparasite or saprophyte to establish a niche for itself, often at the expense of other fungi which it may use as an alternative source of nutrients. It has been clearly demonstrated actively parasitising basidiomycete fungi including *Rhizoctonia solani* (Lewis and Papavizas, 1980), *Armillaria mellea* and *Chondrostereum purpureum* (Papavizas 1985). *Trichoderma*'s biocontrol properties were probably first observed inadvertently in 1914 controlling boot lace fungus, *A. mellea,* after soil fumigation with carbon disulfide. However, not until 1951 was this control demonstrated to be due to enhanced mycoparasitism of the pathogen by *Trichoderma* (Bliss, 1951). Although extensively studied for many decades *Trichoderma* was not registered for commercial use until the 1980s.

Trichoderma has a number of unique properties which have led to its successful commercialisation. Firstly, it is extremely safe with no recorded adverse reactions through a half century of investigations and uses. The strains used commercially will not grow above 33C and, therefore, present no hazard to humans and livestock.

Secondly, it has a wide range of useful antagonistic and parasitic activity towards other fungi, many of which can be harmful pathogens. *Trichoderma* controls the growth of many opportunistic wood-infecting, decay fungi as well as many soil resident fungi causing seedling wilt and damping off diseases. Thirdly, and perhaps most importantly, *Trichoderma* has immunising and protective qualities when resident in a host. It has an ability to survive long term within the host without causing damage to it while imparting a sort of "vaccination" effect which discourages other infecting microorganisms. This property has led to *Trichoderma* being called an immunising commensal (Ricard, 1977). Other examples of common commensal organisms include the nitrogen-fixing bacteria in legume roots and the mycorrhizal fungi associated with many plantation tree roots, both of which assist with nutrient uptake. Once introduced into a woody plant *Trichoderma* can remain active within it for many years offering protection against a range of other microorganisms (Ricard and Highley, 1988).

Trichoderma's parasitic properties towards *C. purpureum*, the fungus causing silverleaf disease, are well described in the literature (Papavizas, 1985; Ricard and Highley, 1988). *Trichoderma* has been shown to actively parasitise the growing *C. purpureum* by wrapping itself around the mycelium, eventually strangling growth and extracting the cellular contents. Ultrastructural observation has confirmed the skeletal acytoplasmic nature of parasitised mycelium (Chet et al., 1981). This process is usually fatal to *C. purpureum* and most often leads to silverleaf disease control in the host plant. Similar parasitic mechanisms have been described for *R. solani* and other fungi. Other mechanisms of biocontrol by *Trichoderma* are less well understood. Some strains of *Trichoderma* have been shown to produce metabolites (antibiotics) with fungicidal activity (Papavizas, 1985).

Much of the work on *Trichoderma* as a commercial biocontrol agent for silverleaf disease in stone fruit trees was performed during the 1970s at the Long Ashton Research Station in England. This work culminated in a registration with the British Pesticides Authority for silverleaf control in 1979. At this time comprehensive research was also performed on various safety and toxicological aspects of the organism to ensure its safety in general horticultural use. One such study showed the LD 50 (lethal dose in mg/kg body weight where 50% of laboratory animals will survive) of *Trichoderma* was less than that of common salt NaCl (Ricard, 1977).

When resident in a host, *Trichoderma* actively inhibits the growth of many other fungi, and while not necessarily destroying them may discourage infection by occupation of the host niche. Among these are the wood-infecting fungi causing diseases, such as, collar rot, *Phytophthora cactorum*; European canker, *Nectria galligena*; and the root-infecting boot lace fungus, *A. mellea* (Fig. 1A). Field results in New Zealand demonstrate that protection of host plants with *Trichoderma* is much more effective than attempts to cure heavily infected plants.

Figure 1A, wood fungi *Trichoderma* is probably more suited to soil colonisation than woody plant colonisation.

Extensive research over two decades into the biocontrol of soil pathogens has been conducted by Papavizas' group at the Beltsville Agricultural Research Station in Maryland, U.S.A. (Papavizas, 1985; Papavizas and Lumsden, 1980). With its extremely rapid growth and copious production of spores *Trichoderma* species quickly colonise the substrata of soils especially after chemical or heat sterilisation treatments. Many strains of the organism, of which there may be over 200, can be isolated from soil in nearly all parts of the world. These growth characteristics have been utilised by incorporating *Trichoderma* and its close relation *Gliocladium virens* into potting mixes and glasshouse soils to minimise problems with wilting and damping off of seedlings caused by fungi, such as, *R. solani*, *Fusarium*, and *Pythium* species (Fig. 1B).

Figure 1B, soil fungi dark bars represent growth on nutrient media plates of various wood infecting fungi (A) and soil-borne fungi (B) unchallenged by *Trichoderma*. Light bars represent growth when challenged with *Trichoderma* under identical conditions. Glasshouse and field trial results from a number of countries suggest there may be significant benefit for some commercial crops by incorporating *Trichoderma* into soil. Recent work conducted at Littlehampton Research Centre in England demonstrated dramatic growth improvement with commercial flower seedlings grown in this way. The suggested mode of action for the *Trichoderma* was that it may have been acting as an adjunct to nutrient uptake. *Trichoderma*'s disease

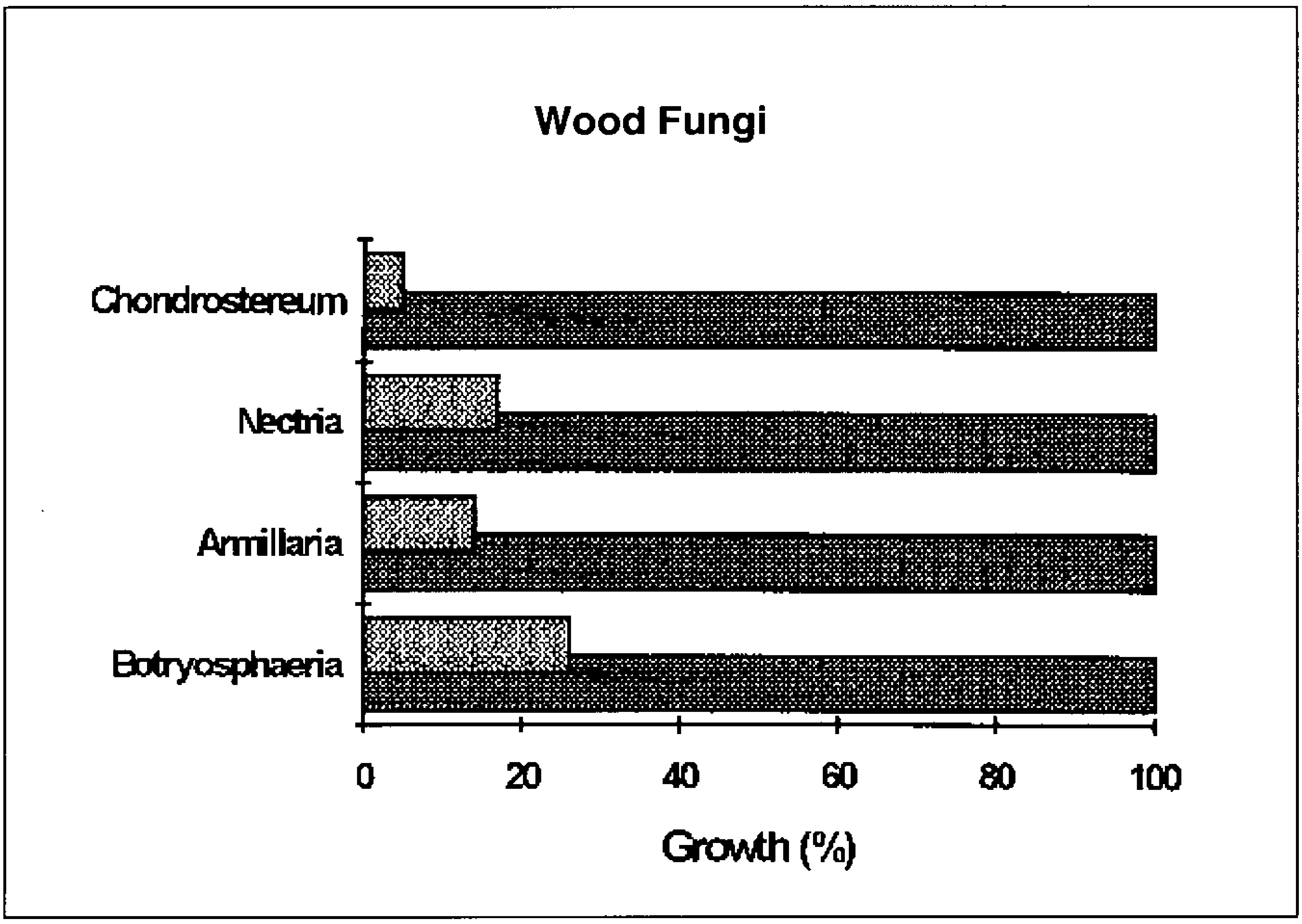

Figure 1A.

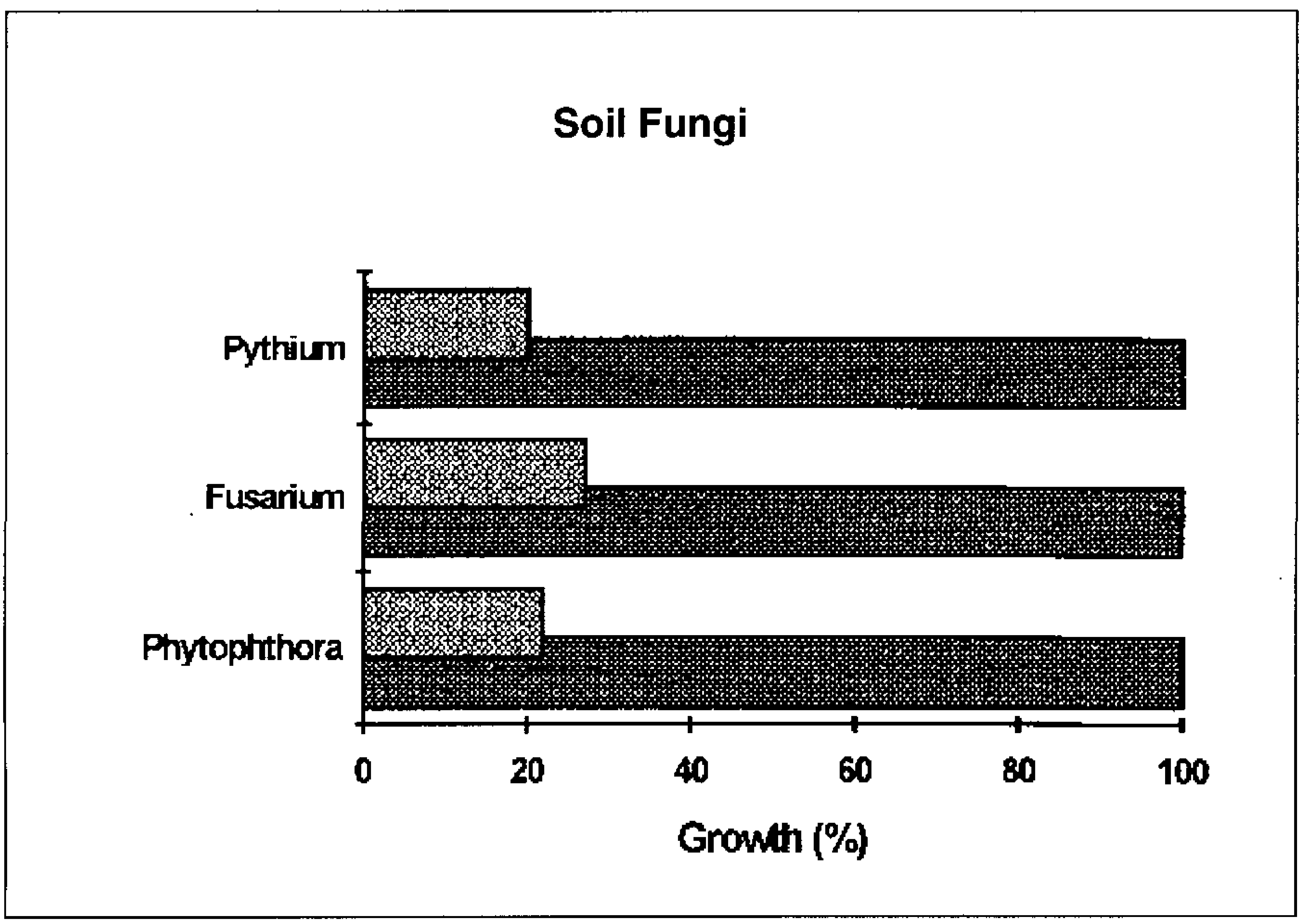

Figure 1B.

protection properties alone would have been unlikely to account for the increased growth observed. Similar results have been obtained in a number of commercial crops in N.Z. Agrimm's *Trichoderma* soil-conditioning pellets (Trichopel) have demonstrated significant growth enhancement and plant health benefits.

Agrimm Technologies product range is now being tested in extended field trials for efficacy against wood-infecting pathogenic fungi such as *P. cactorum* collar rot in various crops as well as *Eutypa lata* and *Botryosphaeria stevensii* dead and dying arm in grapevines.

As an example, Trichoject treatment (10-ml injection) of grape vines infected with *B. stevensii* resulted in clearance of symptoms from 31/45 (69%) of treated vines on assessment the following season (Table 1), which further increased to 90% two seasons after treatment (data not shown). Excellent results in the control of these diseases demonstrated to date in New Zealand are expected to allow Agrimm to both extend its product label claims and crop applications in the near future.

Table 1. Treatment of *Botryosphaeria stevensii* infected grapevines.

		Disease symptoms grade			
Treatment (10 ml)	No. vines	0	1-2	3-5	Mean + s.d.
Trichoject	45	31	12	2	0.5 + 0.9 a*
Trichoject/chemical**	52	8	39	5	1.3 + 0.8 b
Control	52	0	24	28	2.5 + 1.1 c

* Significant difference by Student's t test ($p<0.001$).
** 5ml + 5 ml injection.

Trichopel, a soil-conditioning pellet containing *Trichoderma*, has enabled *Trichoderma* to be placed around plant roots in a form which enables the beneficial fungus to become established in direct contact with the growing root of the plant for the overall benefit of plant health and vigour. Extensive field trials with Trichopel over the past two seasons have shown excellent growth and health improvement in a range of crops, such as, flower bulbs and tubers, tomatoes, strawberries, as well as nursery plants including N.Z. natives and various ornamental trees and shrubs.

As an example, when Trichopel-G (the G is used to denote growing formulation) was added at 200 g m^{-2} to the planting bed of *Sandersonia* tubers, significant live weight gains over untreated control tubers were recorded (Table 2.). These gains were significantly greater when the pellet was closely associated with the tubers (zone) compared with it mixed through the media (mix). Weight gains of up to 35% (data not shown) were recorded from Trichopel treatments in this trial.

Table 2. Trichopel effect on *Sandersonia* tuber weights.

Treatment	Number[2]	Mean wt. (g)	Std. deviation	Significance (p)[1] T v C	M v Z
Mix-200g	6 × 50	8.78	0.63	0.19 ns	-
Zone-200g	6 × 50	10.19	1.26	0.01 s	0.01 s
Control	6 × 50	8.51	0.35	-	-

[1] Significant(s)by Students t Test ($p<0.05$) - individual means. T v C = Test v Control, M v Z = Mix v Zone.
[2] Weights from 6 groups of 50 tubers were recorded.

Attention is currently being focused on the propagation phase of at-risk crops where vulnerability is highest and conditions for *Trichoderma* establishment are most favourable. *Trichoderma* conveniently thrives in temperatures, moisture levels, and a soil/media pH which are most suited to optimum plant growth and development. When Trichopel is introduced, the *Trichoderma* will grow on the nutritive support pellet and if it is sustained by woody plant debris or other humus-type material in the soil/media, will grow rapidly and become established throughout the local environment, eventually producing spores. Trichopel is best applied in close proximity to developing roots of germinating seeds or rooted cuttings. This is easily achieved by broadcasting a layer of Trichopel pellets into the propagation tray immediately below the seed sowing bed or at the final depth of cutting insertion. Pumice propagation media may not sustain the *Trichoderma* beyond the period afforded by the carrier food source, by then it must have become rhizosphere competent in order to maintain beneficial effects.

CONCLUSIONS.

Further applications of the Trichopel technology developed by Agrimm are under evaluation and include the production of a prototype pellet for use in fine turf and a potting mix seeder additive. It is anticipated that the experience gained from current production and use of Trichopel can be utilised to produce cost-effective means of delivering and establishing *Trichoderma* into these and other areas for the benefit of the end user.

Utilising *Trichoderma* as a biocontrol agent does require a sympathetic crop management strategy. Eradicant fungicide additions, powder or drench, to potting media or soil, unless of compatible status, must be avoided or *Trichoderma* will be compromised. However, regular foliar applied fungicide and pesticide treatments targeted at the aerial parts of the plant are unlikely to effect *Trichoderma* resident in the medium/soil next to the plant roots.

Trichoderma's beneficial qualities and effects, together with the further potential for nutritive benefits giving improved vigour and seed germination, should stimulate the growers interest in further evaluating various Trichopel formulations. Many horticulturists will favour the concept of using *Trichoderma* as part of their crop management strategy. Those that do so will not only enhance crop health and vigour, but, will also be contributing to a more sustainable and environmentally sensitive crop production. After all, most of us wish to be part of the solution and not a contributor to future problems.

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