



MycoSolutions  
*inspired by nature*

# Product range

## **Avengelus**

# Background

## What is the story behind MycoSolutions?

The application of *Trichoderma* has been common practice in agriculture for more than 100 years. Prof. Dr. Francis Schwarze (UK), a researcher specialised in wood decay in trees, was and still is curious about the possible impact of *Trichoderma* in the field of tree care. After 10 years of successful research, he and Reto Vincenz founded the company MycoSolutions AG in St. Gallen, Switzerland. Since then, the application of *Trichoderma* has not just been limited to arboriculture, but expanded into the fields of horticulture, lawns, cut flower production and vegetable gardening. For more information on specific projects and research from Prof. Francis Schwarze please visit our homepage: [www.mycosolutions.ch](http://www.mycosolutions.ch) or [www.empa.ch](http://www.empa.ch)

## Where does the name „Avengelus“ come from?

Avengelus is the combination of two names: The first part „Avenger“ comes from Marvel's „The Avengers“. The second part comes from the latin name for angel, „angelus“.

## What makes Avengelus so special?

*Trichoderma atrobrunneum*, the active ingredient in the Avengelus products, is a vital and viable strain originating from Switzerland. We keep our strain vital by frequently training it against the most common pathogens.

Our *Trichoderma* strain is grown on organic natural substrates. These substrates imitate the soil conditions best

from which *Trichoderma* originates. This way of production is far better than on artificial media in fermenters, where *Trichoderma* was found to be less viable.

We set our product quality to the highest standards: all Avengelus products are completely sterile and therefore free from bacteria or other fungi. This results in a long shelf-life of our products.

At the same time, these conditions are most suitable for *Trichoderma* as it does not need to compete with other bacteria or fungi in the product itself or at the time and place of application.

Our different Avengelus formulations (solid, liquid, paste) help the user to apply *Trichoderma* in the most efficient and feasible way.

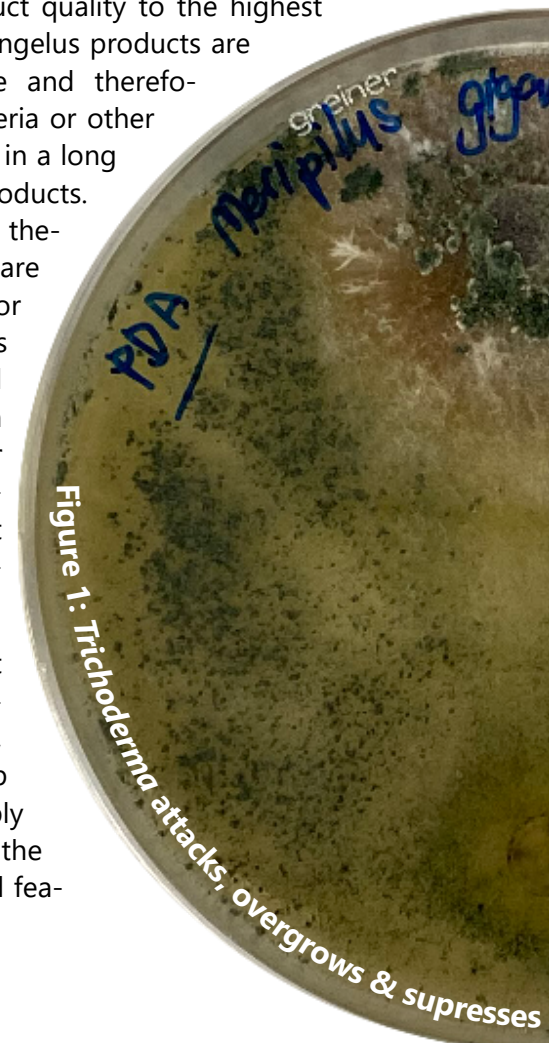


Figure 1: *Trichoderma* attacks, overgrows & suppresses



# Trichoderma atrobrunneum:

## Various mode of actions

*Trichoderma atrobrunneum*, the active ingredient of our Avengelus product range, can make a significant contribution to improving the vitality of plants and to a healthy soil biology.

### Natural antagonist

An antagonist is understood to be a species that competes for space and resources with another species, or strain within a species. *Trichoderma atrobrunneum* is a natural antagonist to many decay fungi.

### Fast growth

*Trichoderma atrobrunneum* is characterised by a short life cycle and high growth rates of up to 2 cm/day in ideal conditions.

By comparison, the growth rates of basidiomycetes for example (division Basidiomycota, which includes the most com-

mon wood decay fungi in trees) usually grow 1 to 2 mm/day and the life cycles range from one to several years.

### Efficient use of space and food

*Trichoderma atrobrunneum* has a high competitive capacity for food and space, as the beneficial fungus can grow quickly and use food sources efficiently. This limits space and other resources to wood decay fungi, which are required for their development.

The optimum temperature for growth and germination is 20-25 °C. The conidia (asexual spores) are pigmented green and can survive under cooler temperatures (such as in winter) by falling into a kind resting state and then germinating again, as soon as the temperatures are warmer (from about 12 °C).

### Parasitising beneficial organism

*Trichoderma atrobrunneum* prefers to remain in the top 20-30 cm of the soil and litter layer, where sufficient nutrients are available. It feeds on dead organic matter, on substances secreted from roots and obtains carbo-

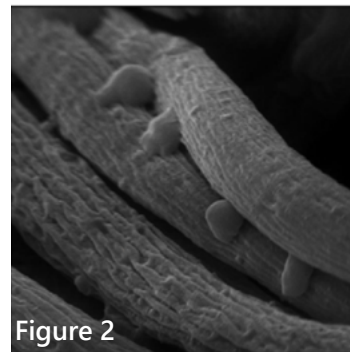
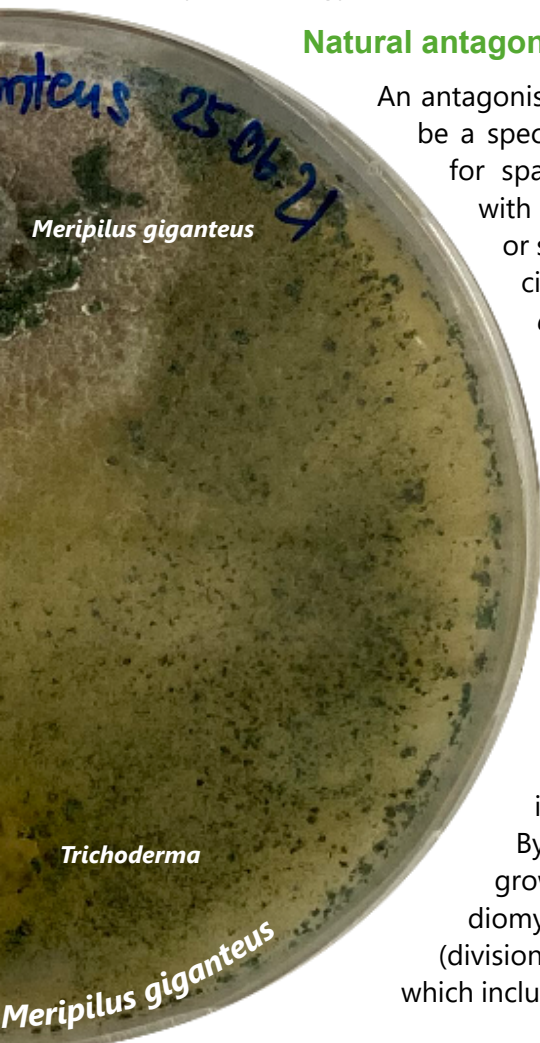


Figure 2

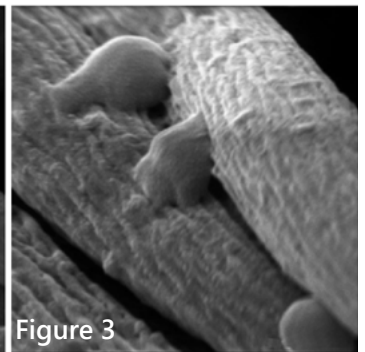


Figure 3

hydrates through parasitism of wood decay fungi. The hyphae of *Trichoderma atrobrunneum* coil around the hyphae of the host (e.g. a decay fungus). Through the secretion of lytic enzymes, the cell walls of the host fungus degrade, while *Trichoderma atrobrunneum* feeds on the cell content (see figures 2 and 3 on page 3).

### **Supports nutrient uptake and promotes root growth**

*Trichoderma atrobrunneum* not only boosts the resistance of plants in unfavourable environmental conditions, but also increases the availability of nutrients present in



the soil. At the same time, various studies have shown that *Trichoderma atrobrunneum* stimulates the development of new roots, which supports the plant in its absorption of water and nutrients. A higher density of fine roots results in an increased water absorption capacity. In this way, *Trichoderma atrobrunneum*, when applied at the right time, can contribute to reduced drought stress.

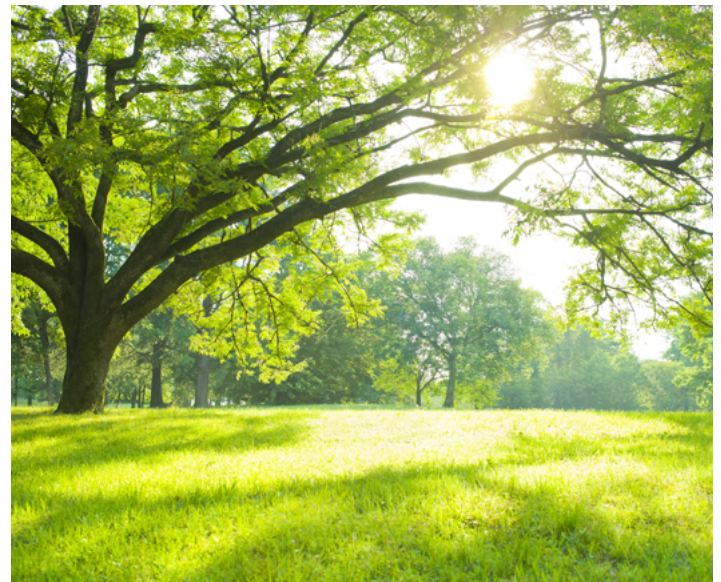
### **Increases stress tolerance**

In times of climate change, plants in our latitudes are



suffering increasingly from drought stress. Many other stress factors affect the vitality of trees in urban areas. Trees in these locations are often pruned improperly, need to cope with limited space, an insufficient nutrient supply, soil compaction, contaminants and microbial imbalance in the soil.

*Trichoderma atrobrunneum* supports plants suffering from these types of stress and can make a valuable contribution to the fields of tree and lawn care, as well as gardening and landscaping.



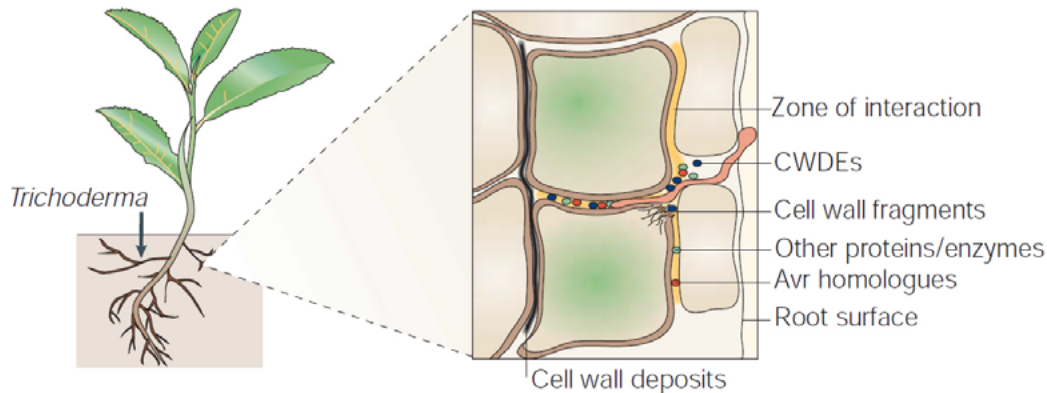
## Pre-immunisation by activation of messenger substances

A plant cannot initially distinguish between a symbiont and a pathogen. At first it responds equally to the infection by strengthening the cell walls and producing so-called phytoalexins (antibodies). *Trichoderma atrobrunneum* establishes a connection with the plant's roots and communicate with the plant through signalling that enables the host to accept it as a beneficial organism.

*ma atrobrunneum* was infected at different times as well as in different locations like the pathogen. The second response of the plant is also called induced systemic resistance or pre-immunisation.

The pre-immunisation resulting from *Trichoderma atrobrunneum* is achieved by intensifying the production of messengers (such as salicylic acid and jasmonic acid), which in turn can trigger the production of phytoalexins. However, the phytoalexins are only produced when a potentially harmful fungus becomes pathogenic.

Figure 4



During root establishment, the beneficial fungus (also known as an endophyte) triggers metabolic and genomic changes in this plant. These changes increase the resistance of the host plant to a wide range of plant damaging microorganisms and insects.

Two observations were made regarding this:

- (1) *Trichoderma atrobrunneum* reduced the infestation where *Trichoderma atrobrunneum* and the pathogen were simultaneously infected,
- (2) There was a reduction in infestation when *Trichoder-*

Figure 4 above from Harman et al. 2004: *Trichoderma* is able to grow between the first two cell layers of the host root. Proteins and enzymes stimulate the production of signalling molecules, which are transmitted in the event of a pathogen attack, triggering a defence response in the plant. (CWDEs = cell wall degrading enzymes)

(Excerpt from Harman, G. E., Howell, C. R., Viterbo, A., Chet, I. & Lorito, M. (2004). *Trichoderma* species – opportunistic, avirulent plant symbionts. Nat. Rev. Microbiol. 2, 43–56.)



# Application information

## How should Avengelus products be used?

For **soil application**: Whether using our liquid formulation (which needs to be diluted in water) or granules (which are added to the planting pit or sprinkled around the crown area), it is recommended to use about 2 ml per m<sup>2</sup> with a water consumption of 0.5-1 L in the application area. It is particularly important to imbibe the spores with sufficient water around the root zone. *Trichoderma atrobrunneum* mainly survives in the top 20-30 cm of the soil. The aim should be to bring the spores as completely as possible into the root area.

For direct **plant treatment**: The liquid formulation is applied at approx. 10 ml per m<sup>2</sup> area per L water. The solid formulation is applied with 0.5 g per L water. It is completely soluble. Apply late afternoon or evening (UV radiation), so that *Trichoderma* can establish itself. When applying to **wounds**, we recommend to apply our liquid formulation undiluted with a brush over the entire surface.

## How often should Avengelus products be used?


Basically, it is better to use small quantities often rather than large quantities all at once. Ultimately, the goal is to achieve a balanced colonisation of roots over a longer time-frame, and thereby maintaining a stable population in the soil. *Trichoderma atrobrunneum* initially builds up large populations in the natural environment, which then shrink during the course of time owing to unfavourable environmental conditions, e.g. drought.

In addition, when several types of microorganisms settle on the root surface, the dominance ratios change over time. An initially strong culture can weaken significantly over time. For these reasons, the multiple application of our products is recommended. Especially for curative treatment in response to pathogenic **wood decay fungi** we recommend 4-6 doses during the vegetation period every 4 weeks. Due to the usually strong colonisation of the harmful fungus, which has occurred over several years, we recommend a multi-year treatment with *Trichoderma atrobrunneum* of at least 4 years. For brushing or spraying with a liquid formulation, we also recommend multiple applications (with a first repetition after 8 weeks) - If possible during rain free periods, otherwise the spores will be washed from the surface. In case of liquid application to **pruning wounds**, *Trichoderma atrobrunneum* populations, especially in the sapwood, can still be found after many months (up to 2.5 years depending on environmental conditions). In case of a direct treatment of the **above-ground plant parts** or the **foliage (incl. lawns)**, we recommend to repeat the application every 2 weeks in case of high infection pressure. Care should be taken that no washing



off spores by heavy watering or precipitation occurs in the first 48 h after application.

### Which temperatures accelerate the effects of Avengelus products?



*Trichoderma atrobrunneum* grows fastest at temperatures between 20 °C and 25 °C. At lower or higher temperatures, growth inhibition occurs. Cooler temperatures do not pose existence problems, but growth slows down. Even temperatures below 0 °C or unfavourable conditions such as drought are no problem for *Trichoderma atrobrunneum* thanks to the formation of chlamydospores. These spores are formed when *Trichoderma atrobrunneum* senses that danger is imminent. Chlamydospores, due to their thick cell walls, are particularly resistant and ensure the survival of *Trichoderma atrobrunneum*. However, compared to the spores, they are produced in much smaller numbers.

### How should Avengelus products be stored?

Avengelus products in liquid and solid form, have a shelf life of 2 years at room temperature (max. 20 °C) and shall be protected from direct sunlight. Do not store be-

low 0 °C.

### Safety instructions

Avengelus products do not contain genetically modified or pathogenic organisms (salmonella, fecal coliform bacteria, aerobic mesophilic bacteria, nematode eggs). Keep out of reach of children and pets. Do not bring into contact with food. May cause sensitization by skin contact. Avoid contact with skin. In case of improper product quality, contact your point of sale.

### Can Avengelus products be mixed with other products?

Avoid mixing Avengelus products with other products that have a pH below 4.5 or above 8. Also, do not mix with bactericidal, fungicidal or phosphate containing products. Avengelus products can be mixed with high quality composts. The compost should not contain any bark mulch, because wood decay fungi can be introduced via bark mulch.

### Further requirements for an Avengelus treatment in tree care

A precondition for a *Trichoderma* treatment is the stability of the trees to be treated. Only when this is given, a treatment with our products is recommended.

A photograph of a golfer on a green, with a golf ball in the foreground. The golfer is in the background, slightly out of focus, holding a club. The sun is low in the sky, creating a strong lens flare and illuminating the scene. The grass is vibrant green, and the overall atmosphere is bright and sunny.

**Large areas and applications per  
hectare**



## Use in lawn care

Lawn diseases can lead to impairment, damage or, in extreme cases, to the destruction of the stand. Lawn diseases are often triggered by inadequate aeration, compacted subsoil, incorrect lawn cutting (too short and/or too often) and nutrient deficiency. If the weather is also favorable to fungi, the lawn is in a bad shape.

## Avengelus, effective against many fungal diseases

Avengelus is effective against a wide range of harmful fungal diseases (dollar spot, brown spot, summer fusariosis, fairy rings, etc.). The application of different fungicides in alternating sequence is no longer necessary.

## No development of resistance

The strain contained in Avengelus does not produce antibiotics and grows faster than most harmful fungi. These are the reasons why pests do not adapt to *Trichoderma* and *Trichoderma* can build resistant populations or generations.

## Difference between PROFESSIONAL to our other Avengelus products

Compared to the other liquid formulations from the Avengelus product range, PROFESSIONAL is adapted to the needs of the professional sector. With an increased concentration of spores,  $10^9$  CFU\* per ml instead of  $10^8$  CFU per ml, a whole hectare can be treated with a 1 L bottle.

## Simple application

**Preventive against fungal infestation in the soil:** Spores must reach the roots in the top 5-15 cm of the soil. Application takes place with a dosage of 0.1 ml per m<sup>2</sup> treatment area, every 8 weeks during the vegetation period.

**Treatment of soil-borne harmful fungi:** If harmful fungi are already present in the soil, *i.e.* in the root zone of the plant, the frequency of application is increased to every 4 weeks. The treatment should be carried out for 3-5 years, depending on the harmful fungus and its life cycle. The dosage remains at 0.1 ml per m<sup>2</sup> of treatment area (or 1 L per ha) and should be applied with a water input of 600-800 L per ha.

**Treatment of leaf diseases:** For foliar diseases, which can spread very quickly, Avengelus PROFESSIONAL is applied every 2 weeks with 1 ml per L of spray broth per m<sup>2</sup>. The water application should not exceed 400 L per ha, so that the spores remain on the leaf and are not washed into the soil.

## Prolonged duration of action

With sufficient moisture and temperature, *Trichoderma atrobrunneum* grows and thrives as a natural microorganism. Fungicides, on the other hand, always degrade over time.

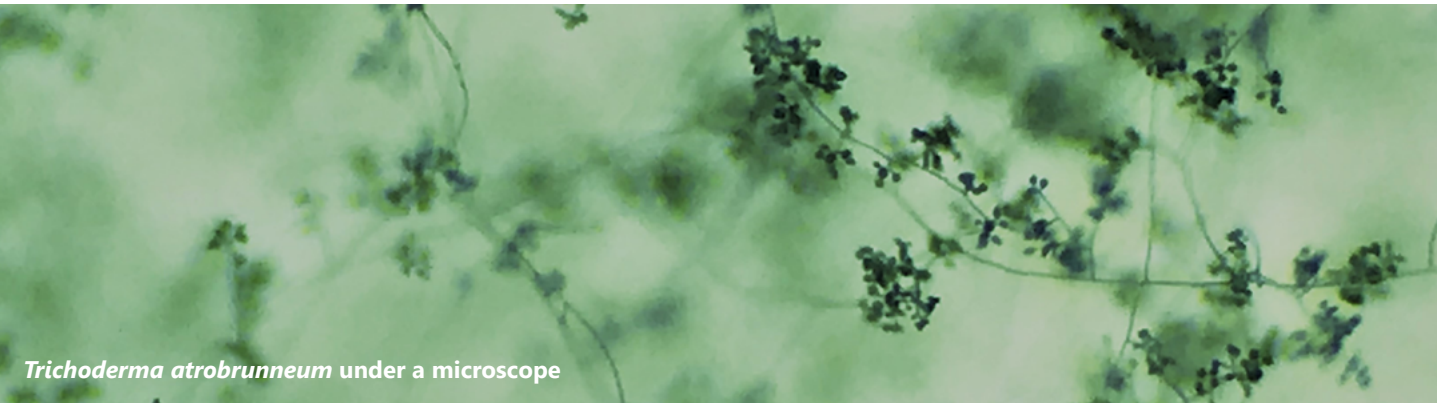


\*CFU = colony forming units, is a unit to estimate microorganisms, such as *Trichoderma*. Spores can be found singly or in groups of spores (colonies).

# General application rates

This table provides an overview of dosage rates per product type. It is important to apply *Trichoderma* products frequently to achieve a balanced colonisation of roots and soil over a longer time-frame. Only a stable population in the soil is able to support plants and soil. Therefore, we recommend applying *Trichoderma* 4-6 times a year over several consecutive years. For a more detailed advice, please see your local distributor.

Product name	Concentration	Soil application liquid	Soil application dry	Foliage application liquid
Avengelus granules	10 <sup>7</sup> CFU/g	0.5 g in 1 L water	5 g per m <sup>2</sup> soil	5 g in 1 L water
Avengelus suspension	10 <sup>8</sup> CFU/g	2 ml per m <sup>2</sup> soil	-	10 ml in 1 L water
Avengelus Professional	10 <sup>9</sup> CFU/g	0.1 ml per m <sup>2</sup>	-	1 ml in 1 L water
Avengelus Tree balm	10 <sup>8</sup> CFU/g	-	-	undiluted



*Trichoderma atrobrunneum* under a microscope



Need Help?

Contact your local Distributor should you wish to discuss your particular project or require more information on the use and application of Avengelus products.

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