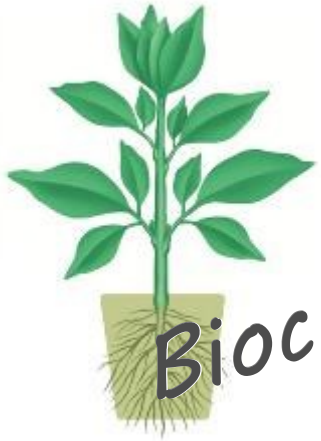

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Biocontrol Using *Trichoderma*

What is *Trichoderma*?

Trichoderma species are fungal organism that can help farmers grow better crops and have higher income while protecting the soil environment. They are living freely in soil in agricultural and natural environments worldwide.

Commercial products have been developed for plant protection that contain special strains of living *Trichoderma* species, mostly *Trichoderma harzianum*. They have been formulated in a way that farmers and growers can easily apply them in the field. It is a safe and effective **biocontrol agent** (BCA) that can control a variety of fungal (and bacterial) diseases, such as wilt, damping off, stem rot, and downy mildew.

But not only that! *Trichoderma* is a **yield-booster** that makes crops look healthier, grow bigger, and show better root development.

How is it doing this? *Trichoderma* works best in the soil. It is a biological degrader and competitor of fungal plant pathogens, which has evolved mechanisms for attacking other fungi in the root zone of a plant. Beyond that it also improves nutrient uptake of plants.

Trichoderma harzianum

Farmer in Kampong Chang, Cambodia: She can harvest bigger eggplants because she applied *Trichoderma*.

How *Trichoderma* works

As a biocontrol agent, the three most important antagonistic processes of *Trichoderma* spp. include:

* *Antibiosis*: metabolites that inhibit or kill other microorganisms
* *Mycoparasitism*: direct interaction with other fungi through attachment and secretion of lytic enzymes
* *Competition*: with pathogens and other fungi for food

When *Trichoderma* spp. colonize plant roots they can stimulate plant growth and protect against infections

HANDS-ON GUIDANCE ON IMPLEMENTING BIOCONTROL AND IPM

Inside this issue:

WHY AND WHEN SHOULD I USE *TRICHODERMA* ?

You should use *Trichoderma* species when you have problems with soilborne fungal pathogens. Rotting (disintegration of parts of a plant), damping off (rapid death and collapse of very young plants), and wilting (loss of turgidity and drooping of leaves or shoots) is often caused by such soil pathogens. *Trichoderma* spp. is most effectively used as a plant strengthener for seed and seedling diseases, less so against disease of mature crops. Especially, seed treatment (coating) is highly recommendable.

There is also evidence that *Trichoderma*-based products are effective for controlling bacterial (vascular) wilts; for instance bacterial wilts of cucurbits (caused by *Erwinia tracheiphila*, e.g., in cucumber and pumpkin) or bacterial wilts of solanaceous crops (caused by *Ralstonia solanacearum*, e.g., in tomato, eggplant, potato). However, bacterial wilts are best managed with products containing biocontrol agents such as *Pseudomonas fluorescence* or *Bacillus subtilis*, or by combining these with *Trichoderma* spp.

Yet, there is another reason to use *Trichoderma*: Are you seriously interested to increase your yield? *Trichoderma* has been shown to improve nutrient uptake by plants. Crops just grow bigger and healthier (see page 3).

Trichoderma effective against various fungal pathogens

Alternaria alternata	Leaf spot and other diseas-
Aspergillus niger	Black mould on fruits
Aspergillus flavus	Post-harvest rot on cereal grains, legumes, and tree nuts
Botrytis cinerea	Grey mould disease on fruits
Colletotrichum spp.	Anthracnose in various fruits post-harvest
Fusarium spp.	Wide range of fugal infections causing wilting and rotting; e.g., on cereals, banana, vegetables etc.
Phytophtora spp.	Blight in potato and tomato, soybean root rot, and many other crop diseases
Pyricularia oryzae	Rice blast pathogen
Pythium spp.	Damping-off, root rot, stem rot
Rhizoctonia solani	Damping-off in seedlings, black scurf of potatoes, bare patch of cereals, root rot of sugar beet, belly rot of cucumber, sheath blight
*Sclerotium (*syn. with *Typhula)* spp.	Blight of cereals and other crops

PLANT DISEASES IN PICTURES

Downey mildew of cucumber

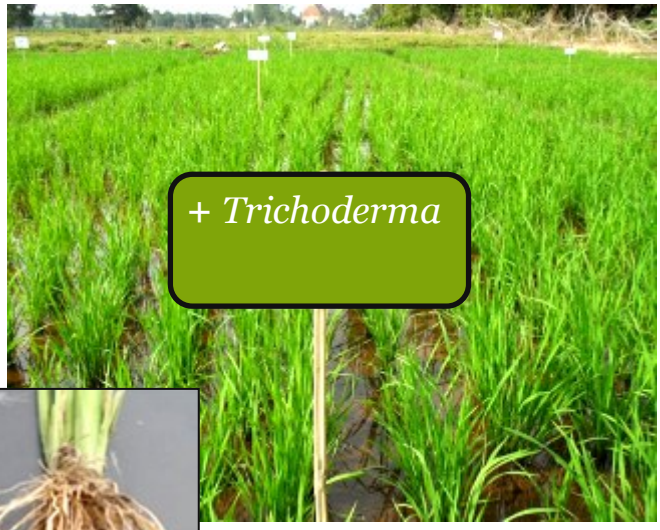
Bacterial wilt

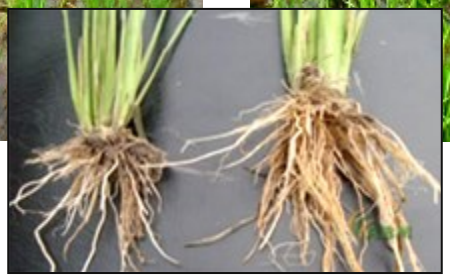
Bacterial blight

Rhizoctonia sp. on bean

Fusarium wilt

BIOCONTROL USING TRICHODERMA





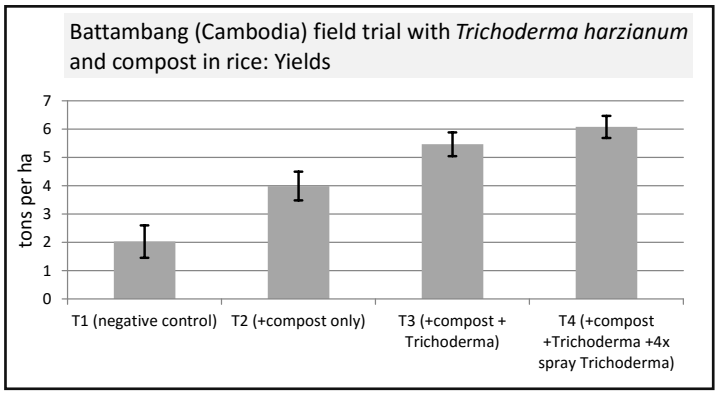
HOW EFFECTIVE IS *TRICHODERMA* ?

ASEAN Sustainable Agrifood Systems (SAS) Project conduced field demonstrations in rice in collaboration with the Cambodian Department of Agriculture, and in vegetables in collaboration with the USAID program HARVEST in Cambodia. Some of the results are shown here. Clearly, using *Trichoderma* spp. as a stand-alone agent, or in combination with compost or manure can significantly boost yields in rice and vegetables. Applying compost alone could already double, in combination with *Trichoderma* spp. even triple yield in rice! (see graph on the right)

In vegetables, the project witnessed a average yield increase of 17.4% in cucumber, and 11.8% in bitter gourd (see below).

Rice and vegetable crops appeared bigger and healthier under treatment with fungal biocontrol and showed no or reduced disease symptoms.

"*TRICHODERMA* AND COMPOST ARE YIELD BOOSTERS"



Weight of 10 cucumber seedlings taken randomly from non-treated and *Trichoderma*-treated fields: 31 g versus 51 g

HOW TO APPLY *TRICHODERMA* ?

Products containing *Trichoderma* species are best used as soil amendments, sometimes also as foliar sprays.

Most importantly, these biocontrol agents work best, if they do not have to compete with already established communities of soil microorganisms. Then, the fungus grows rapidly and can outcompete other microorganisms. Therefore, *Trichoderma* spp. is best introduced during the seedling stage and early growth phase of plants, and in materials (like compost) conductive for growth. Organic fertilizer, cow manure, or rice-straw compost have all been found to be useful carrier-materials for *Trichoderma* spp.

Temperature and humidity are important factors to consider when applying this BCA in the field. For instance, *Trichoderma harzianum* grows well at 30 C and below, but cannot tolerate more than 36 C. This means application in the field should be carried out towards the evening, best after having irrigated or sprinkled the crops.

Many *Trichoderma* products should be stored cool to extend their shelf life, which can reach one year if kept in the refrigerator.

Examples for application rates are given in the table below.

The images on the right illustrate in some detail how *Trichoderma* spp. is handled for application in the field or green house.

"Trichoderma is best used as a soil amendment during the early growth phase of crops"

EXAMPLES FOR APPLICATION RATES OF *TRICHODERMA* SPP.

Product	Formulation (concentration of conidia)	Application rate	Compost application rate
T. harzianum (e.g.; strain produced in Cambodia by GDA)	1 x 10^7 CFU/g (powder)	• With compost: 1 kg powder mixed with 1000 kg compost • As foliar spray: 20 g/20 l water	RICE: 5—20 tons/ha (= 0.5—2 kg/m²) VEGETABLES: 2 kg/m²
T. harzianum (e.g., 'Trisan', AppliedChem Thailand; strain AP-001)	2 x 10^8 CFU/g (powder)	• Drenching or spraying on plant: 30-50 g/20 l water	
T. viride (e.g., 'Bio-Cure'; T Stanes, India)	2 x 10^7 CFU/g (powder)	• 5—8 kg/ha (= 0.5—0.8 g/m²) • With compost: 4 kg in 1000 kg compost or organic fertilizer • Seed dressing: 8 g/kg of seeds along with stickers • Seedling treatment: 20 g/l of water. Roots are dipped into solution for 30 min prior to planting.	

METHODS OF APPLICATION

Application during the seedling stage:

1) Mixing (wettable) powder with water
2) Spraying seedlings using knapsack sprayer

During/after transplanting:

3) Application at transplanting
4) 10 days after transplanting using an injection valve through the drip irrigation system

5) Mixing *Trichoderma* with compost

Stir the *Trichoderma* powder formulation in water until it is completely suspended at a rate of 1 kg per ton of compost.

The compost should be kept moist (not wet), so that the fungal biocontrol agent has optimal growing conditions. Cover the compost heap with a plastic sheet or similar and keep it in a shaded place. If possible, place the compost on a support (e.g., a palette) that allows access of air underneath the heap.

Within 4-5 days of inoculating the compost with *Trichoderma*, successful development will be indicated by a whitish layer on the compost, which is the growing fungal mycelium.

BIOCONTROL/IPM AND FARM ECONOMICS

The main indicators for measuring economic sustainability from a producer's point of view (livelihood) include revenue, costs, and income.

Biocontrol agents (BCA) like *Trichoderma*, and other plant protection inputs are production factors that are accounted for under (variable) costs.

Unfortunately, mis– and overuse of synthetic inputs has created a situation where the farm depletes the productive capacity of its natural and human resources, which is not economically viable.

Ecological, social, and economic integrity; each of the three is necessary but only all three together, in harmony and balance, are sustainable.

The economic bottom line places a premium on the present (relative to the future). This is why investment in the (mid to long term) environmental sustainability is not adequately valued.

Only based on this integrity can sustainable farm management maintain and improve competitiveness (sales, inputs, personnel, finance) in order to generate financial surplus and safeguard farm operations in the long term.

BCA help to protect ecological integrity and can replace synthetic pesticides that threaten human and environmental health. Besides, they are also pretty effective (see page 3), securing financial surplus.

It is the goal of Integrated Pest Management (IPM) including BCA to prevent losses due to pests and diseases while minimizing input costs.

To that end, we discuss in the following some strategies how this can be achieved.

"Trichoderma increases productivity - and profits"

FAQ: Pest Management and its Economics in Farm Production

Can pest and disease management increase crop yields?	No. Pest and disease management can only reduce losses, which are caused by pests and pathogens. For lowland rice, estimates indicate an absolute yield loss of 1-2 tons per ha.
If I want a higher yield, what can I do?	Focus your attention on improving soil health and nutrients. Increasing soil organic matter is key to stabilizing and improving soil structure. Low tillage, maintaining soil cover (through crops, crop residues, cover crops, rotations) and applying compost or manure can all contribute to better soil health and, ultimately, higher yields. *Trichoderma* also has a yield-increasing effect. Thus, it can be used as an amendment for improving soil.
Are insect pests the most important pest?	Not always. In rice, the role of insect pests is generally over-estimated. Rodents and weeds are often more damaging. Vegetables and fruits can suffer from heavy insect pest attack, but plant diseases are also important. Note: Some insect pests are a problem because of overuse of pesticides (e.g. diamondback moth); here, pesticides are not the solution, but the problem! Pesticide overuse is a major driver for increasing input costs. Fungal diseases often become more important during the wet season, especially when the cropping pattern (e.g. spacing of plants too narrow) supports fungal growth. Insect pests are best kept in bay by promoting natural enemies.
When is application of BCA most economic?	Application of BCA is most effective and economic at a moderate to low pest and disease level (targeting larval or early stages of pests) in a preventive rather than reactive manner. This reduces application rates.
What is the economic threshold level?	If the yield that I loose if I do nothing is more worth than the cost of plant protection, then I could apply plant protection measures. However, I have to understand the pests and natural enemies involved, plant tolerance and ability to compensate for damage, other investment opportunities, and expected climatic conditions (weather forecasts).

PROFITABILITY OF CROPS: FIELD EXPERIENCES FROM SAS

Source: UTT Center for International Trade

ofitability of Growing Rice

PARISON AMONG THREE COUNTRIES IN 2012

	Thailand	Vietnam	Myanmar
uctivity (t/ha)	2.8	5.6	2.6
(US$/t)	307	128	224
nue (US$/t)	356	228	334
t (US$/t)	49	100	110

Apart from *Trichoderma* (see page 3) SAS has conducted other field trials and demonstrations in different food and cash crops, including:

- Control of flea beetle using *Bacillus thuringiensis* var. *tenebrionis* and entomopathogenic nematodes in cabbage (Thailand, Brunei Darussalam).
- Control of fruit fly (*Bactrocera* species) in fruit trees by mass trapping using attractants (Indonesia).
- Control of stem borers in rice using sex pheromones (Indonesia).
- Control of coffee berry borer by mass trapping with attractants (Indonesia).

The field experience has shown that with regard to input costs and in relation to crop productivity application of BCA are competitive or even cheaper than synthetic inputs.

Because farmers mis– and overuse synthetic inputs, the alleged advantage of synthetics of being cheaper does not result in higher income of farmers. On the contrary, farmers do experience losses, if the balance between input costs and crop productivity is not right. Degraded soils and pesticide-induced phytotoxicity further attest to this approach as being unsustainable.

The boxes on this page present examples of simplified profit and loss sheets for rice and vegetables (cabbage). For instance, case studies in cabbage have shown that input costs (including labor) varied between 121% (effectively a loss) and 55% of the revenue (see box below).

In rice, input costs varied between 56% and 86% of the revenue in an inter-country comparison (see above). However, productivity of rice is much lower than that of cabbage or other vegetables. Hence, input costs are much more critical in rice and every measure should be taken to reduce costs.

Because *Trichoderma* not only reduces crop losses due to plant disease but also increases yields (productivity), these fungi are very well suited to improve revenue. If *Trichoderma* is properly applied with compost, it can reduce or substitute expensive synthetic fertilizer.

In view of its soil health promoting properties *Trichoderma* is a truly sustainable approach.

HOW TO REDUCE INPUT COST?

Pesticides

- ◊ Reduce number of sprays to 2 or less, considering action at low to medium pest & disease levels. Sometimes control is useful even before planting.
- ◊ Protect natural enemies by not spraying if not necessary. For instance, in rice do not spray the first 30 days.
- ◊ Use biocontrol instead of synthetic pesticides if possible
- ◊ Spraying at pest outbreaks is useless
- ◊ Do not listen to arguments aiming at creating fear: Even by doing less you will not loose your entire crop!
- ◊ Crop rotation (or mixed cropping) will reduce pests & diseases, diversify your farm production, and increase your income.

Fertilizer and Soil

- ◊ Determine your soil fertility
- ◊ Adjust fertilizer applications according to fertility status
- ◊ Use compost or manure to improve soil health
- ◊ Reduce tillage and maintain soil cover to increase soil organic matter

INPUT COST AND PROFIT FOR GROWING VEGETABLES

(Examples from Thailand extrapolated to 1 ha)

Item	Cabbage (*Case 1*)	Cabbage (*Case 2*)
Productivity (t/ha)	**20.3**	**23.0**
Inputs (Costs) (US$/t)	**324 / 246#**	**156 / 160#**
* Labor etc.	* 146	* 108
* Fertilizer	* 90	* 36
* Pesticides /or Bio-control#	* 88 / 9.8#	* 12 / 16#
Revenue (US$/t)	**267**	**283**
Profit/Loss (US$/t)	**- 48/21#**	**127 / 123#**

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