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Biological Control of Cacao Disease with Beneficial Bacteria

Cacao (*Theobroma cacao* L.), the tropical tree crop from which chocolate is produced, is susceptible to several diseases that can severely diminish productivity and yields. Three of the most devastating threats to cacao – black pod rot, witches broom, and frosty pod – are all caused by fungal pathogens. Controlling these diseases with chemical pesticides is prohibitively expensive, particularly for small-scale farmers. The chemicals also carry significant environmental and human health risks.

The cacao tree, also called the cocoa tree, is a small evergreen native to the tropics.

Chocolate is made from cocoa beans, the seeds found in the fruit pods of the cacao tree.

Biological Management of Cacao Disease

Biological control agents (BCAs), such as beneficial bacteria that provide disease resistance when applied to crops, are one promising solution to cacao diseases. Recent research has found some success with using bacteria living within plant tissues from one plant species and applying them as a BCA to an entirely different plant species. In this vein, SANREM researchers tested four different *Bacillus* species that have been used to manage disease in other crops. Two of the bacteria species (BacJ and 203-7) were isolated from sugar beets, one from potato (BP24) and one from tomato plants (BT8). Specifically, the researchers assessed the ability of each bacterial species to 1) colonize cacao leaves, and 2) reduce the occurance of black pod rot caused by the pathogen *Phytophthora capsici*.

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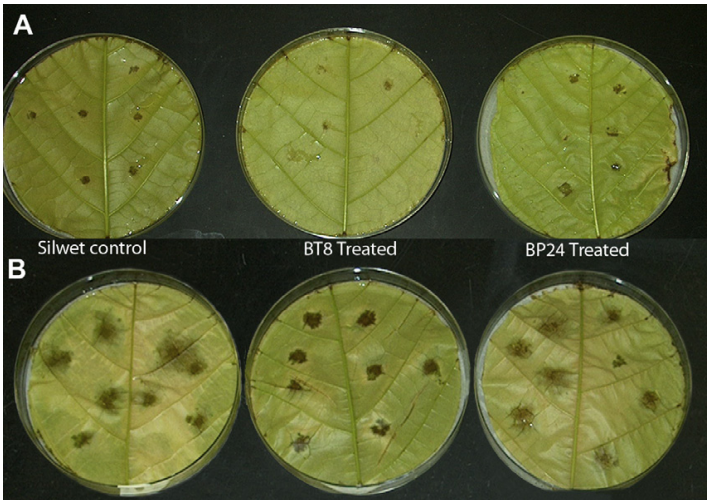
Evidence of induced systemic disease resistance

Bacterial induced disease resistance can happen directly through antagonism of the pathogen, or indirectly through the bacteria turning on plant defenses. To determine if any of the *Bacillus spp*. had a direct antagonistic effect on the black pod rot pathogen, the researchers combined samples of each bacteria species and the pathogen in a laboratory test to assess if the presence of the bacteria would limit the growth of the *P. Capsica* pathogen. They did not find any significant effect of the bacterial isolates on the pathogen growth, suggesting that there is not a direct effect.

Black pod rot, caused by *Phytophthora spp.* pathogens, is prevalent worldwide and causes substantial yield losses each year.

In the second part of the study, cacao tree leaves were wetted using an aerosol sprayer containing the *Bacillus* bacteria and a surfactant; the leaves were then evaluated over time to assess bacterial colonization. Of the four *Bacillus* species, only BP24 and BT8 persisted as long-term colonists on the cacao leaves. The colonization was primarily on the surface of the plant leaves and only occured on the leaves that were directly sprayed – no bacteria transferred to new growth that emerged after the bacteria application.



Leaf discs (YG stage) challenged with 10 microgram suspension of *P. capsici* zoospores (50 per droplet) 45 days after cacao plant colonization with either *Bacillus cereus* BP24 or BT8 applied with Silwet surfacent.

Although both *Bacillus* species successfully colonized the cacao leaves, only one (BT8) reduced the disease severity of black pod rot; the other (BP24) had no measurable effect. Interestingly, the disease resistance of cacao plants colonized with BT8 was only evident on the younger leaves that had no bacterial colonists. This suggests that the bacterial colonization induces a systemic resistance, with a signal originating in the colonized mature leaves and triggering resistance in the immature, uncolonized leaves.

Beneficial bacteria such as BT8 and BP24 form endospores in response to stress, but with differing results. BP24 formed few endospores, suggesting that the bacteria did not trigger the plant's defenses. In contrast, BT8 did develop endospores, and disease resistance correlated to endospore population. This is further evidence that *Bacillus spp*. provide disease resistance through inducing the plant's systemic resistance.

Potential Applications

Applying Bacillus spp. as a BCA would likely be more enduring and require fewer applications than chemical controls.

The Bacillus spp. tested in this study are not native to cacao or the tropics. With environmental and regulatory concerns of introducing new bacteria to these regions, it will be necessary to identify endospore-forming bacterial endophytes that occur naturally on cacao and test those for induced disease resistance. Native bacteria will likely be more effective than BT8 at reducing disease.

More information: Melnick, R.L., N.K. Zidack, B.A. Bailey, S.N. Maximova, M. Guiltinan and P.A. Backman. 2008. Bacterial endophytes: Bacillus spp. from annual crops as potential biological control agents of black pod rot of cacao. Biological Control 46(1): 46-56 http://dx.doi.org/10.1016/j.biocontrol.2008.01.022

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