Mushroom Compost to battle against nematode pests on vegetable crops

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Fig 1. *Pleurotus ostreatus* (left) and *Pleurotus eryngii* (right).

Introduction

Plant-parasitic nematodes are prevalent pests in nearly all vegetable crops in tropical climates in Hawaii (Schmitt and Sipes, 1998). Many farmers are looking for alternative methods to chemical approaches for managing nematodes in the soil. Oka (2010) had reviewed the effects of a series of organic amendments including animal and green manures, compost, and nematode-antagonistic plants on suppressing plant-parasitic nematodes. A type of compost that is known to secrete toxic compounds against nematodes but has not received enough attention is the oyster mushroom compost. Gray oyster (*Pleurotus ostreatus*) and King oyster mushrooms (Ali'i) (*Pleurotus eryngii*) (Fig 1) are two common commercially produced oyster mushrooms in Hawaii. *Pleurotus ostreatus* is known to exude a toxin from the fungal hyphae, known as trans-2-decenedioic acid (Kwok, 1992). This toxin paralyzes the nematodes on contact, which allows the hyphae to move into position to colonize and digest the nematode. Studies on the effects of oyster mushroom on nematodes have been predominantly *in vitro*. Palizi et al. (2009) demonstrated the use of mushroom compost with sugar beets (*Beta vulgaris*) in the field by directly incorporating the mushroom compost into soil at 3% (w/w). The mushroom compost suppressed more than 85% of sugar beet cyst nematode (*Heterodera schachtii*) cysts. Although direct incorporation of the mushroom substrate into the soil could ensure direct contact of the mushroom mycelia with the root system, the amendment rate needed for nematode suppression using this approach could be unfeasible in the field- or even at the garden-scale if ample supplies of the mushroom compost are not available. A WSARE funded project looks into the potential and feasibility of using mushroom compost waste as an organic approach to manage plant-parasitic nematodes in Hawaii where commercial production of oyster mushroom is not overly abundant.

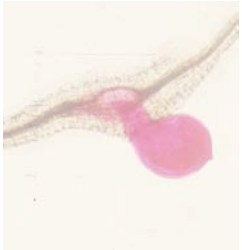

Fig 2 Infection of root-knot nematode on a root system.

This project is exploring different approaches to use mushroom compost for the suppression of root-knot nematodes (*Meloidogyne incognita*) through: 1) direct incorporation of the mushroom substrate into the soil before crop planting, 2) drenching mushroom compost water extract into the root system after crop planting, and 3) amending mushroom compost into the growth media of transplant trays. Several factors might affect the applicability and efficacy of nematode suppressive effects of mushroom compost. These include mushroom species, mushroom compost amendment rate, concentration of mushroom compost extracts, and local availability of the compost.

Use of mushroom compost as direct soil amendment

A greenhouse experiment was conducted by directly amending spent mushroom compost at 0, 0.25, 0.5, or 1% (w/w) into a 1:1 (v/v) sand: soil mixed media. The compost was harvested from Gray oyster mushroom (*P. ostreatus*) culture on brewed coffee grounds 3 months after inoculation. Basil (*Osimum basillicum*) seedlings were transplanted into 15-cm diameter pots containing sand: soil mix amended with these amendment rates. The experiment was arranged in a completely randomized design with 5 replications. Second stage (J2) juveniles of *M. incognita* were inoculated at 200/pot. At 10 weeks after nematode inoculation, shoot and root weight of basil were recorded. Nematode eggs were extracted from the roots using the NaOCl shaking method (Hussey and Barker, 1973), counted and hatched in Baermann trays (McSorley and Frederick, 1991). Nematodes in the soil were extracted using elutriation and centrifugal flotation method (Byrd et al., 1976). Nematodes were counted under an inverted microscope (Leica, DMIL).

Fig 3. Basil roots infected by root-knot

Unfortunately, this direct mushroom compost amendment did not suppress *M. incognita* on basil roots and soil (data not shown). In fact the numbers of nematodes/g root were higher ($P < 0.05$) in plants with mushroom compost amendment than the un-amended treatment (Fig. 3). It is possible that poor establishment of the mushroom mycelium in the sand: soil mix with limited organic matter resulted in no suppression of the nematodes. This result would resemble a scenario where oyster mushroom compost were to be amended directly into a field soil with low organic matter. Agriculture soils generally contain less than 1-6% organic matter (McClellan et al., 2007).

Use of mushroom compost as transplant media mix

Since directly amending mushroom compost into soil containing low organic matter resulted in poor performance in nematode suppression, the second approach to be examined was to use mushroom compost as transplant media mix. Transplant media such as peat moss or yard waste compost usually contains a high amount of organic matter. Peat moss contains at least

80-95% organic matter (Marrush, 2007). The next logical step was to amend mushroom compost into this medium and determine the amendment rate or time required for the mycelia to colonize the medium before transplanting into the field. We hypothesized that a growing medium successfully colonized by oyster mushroom mycelia would incapacitate more nematodes and thus better protect the seedlings from nematode infection.

A Cone-tainer tube experiment was conducted by amending spent mushroom compost of *Pleurotus eryngii* obtained from Hamakua Heritage Farm (Laupahoehoe, HI) into yard-waste compost medium (Hawaiian Earth Product, Ewa Beach, HI) at 50, 33, or 0% (w/w) using Cone-tainer tubes (Ray Leach Cone-tainer, Corvallis, OR) (Fig. 4). To determine the incubation time for the mushroom compost to suppress root-knot nematodes, 80 nematode juveniles were added to each tube and incubated for 1, 4, 7, or 30 days. Nematodes were then extracted by incubating the medium in Baermann trays for 7 days.

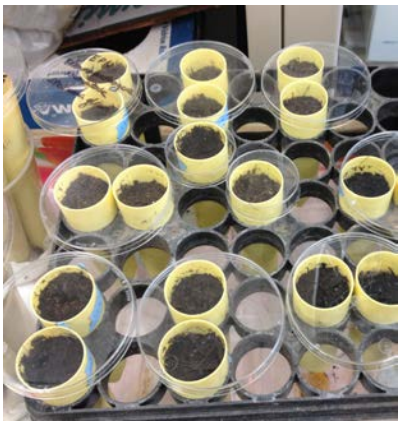

Fig 4. Cone-tainer tubes with mushroom compost amended in Hawaiian Earth Product media.

Results revealed that both 50 and 30% compost amendment rates have a higher percentage of inactive *M. incognita* than the un-amended control (Fig. 5A). At least 7 days of incubation was needed to suppress *M. incognita* activity compared to 1 day of incubation (Fig. 5B).

A second Cone-tainer experiment was conducted by planting zucchini seeds into Cone-tainers containing Hawaiian Earth Product compost amended with spent mushroom compost of either *Pleurotus ostreatus* or *Pleurotus eryngii* at 1, 2, 33, or 50% (w/w). Zucchini seeds were allowed to germinate and grow for 1.5 weeks before inoculating 200 *M. incognita* per tube. Experiment was terminated one-week after nematode inoculation.

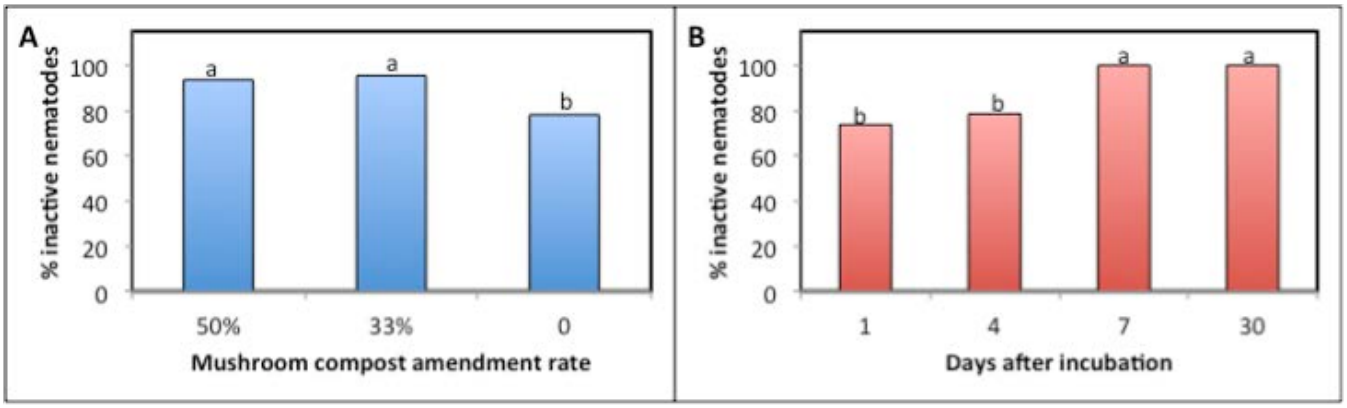

Fig 5. Effects of A) amendment rate mushroom compost of *Pleurotus ostreatus* and B) incubation time of nematode in mushroom compost on suppression of root-knot nematodes. Means are average of 5 replications. Columns followed by same letters are not significantly different based on Waller-Duncan *k* ratio (k=100) *t*-test.

At termination of this zucchini experiment, regardless of mushroom species, 1, 33, and 50% amendment rate suppressed *M. incognita* numbers in the media (Fig. 6A). However, mushroom amendment did not reduce *M. incognita* penetration into the zucchini roots (data not shown). Although compost of *P. ostreatus* suppressed *M. incognita* slightly better than *P. eryngii* (Fig. 6B), *P. eryngii* enhanced root growth better than *P. ostreatus* (Fig. 6C).

Use of mushroom compost water extract as soil drenching solution

Mushroom compost of *Pleurotus ostreatus* was soaked in water at 50, 33, and 25% (w/w) and aerated overnight to prepare mushroom compost water extracts. Toxicity of these water extracts against root-knot nematodes were conducted in petri dishes and compared to water control (Fig. 7). Nematodes were incubated for 1, 2, 3, 4, or 5 days prior to examination of active and inactive nematodes. Nematodes in each dish were then rinsed with water and incubated in water for a day and counted again after washing to determine whether the nematode can recover from the toxicity.

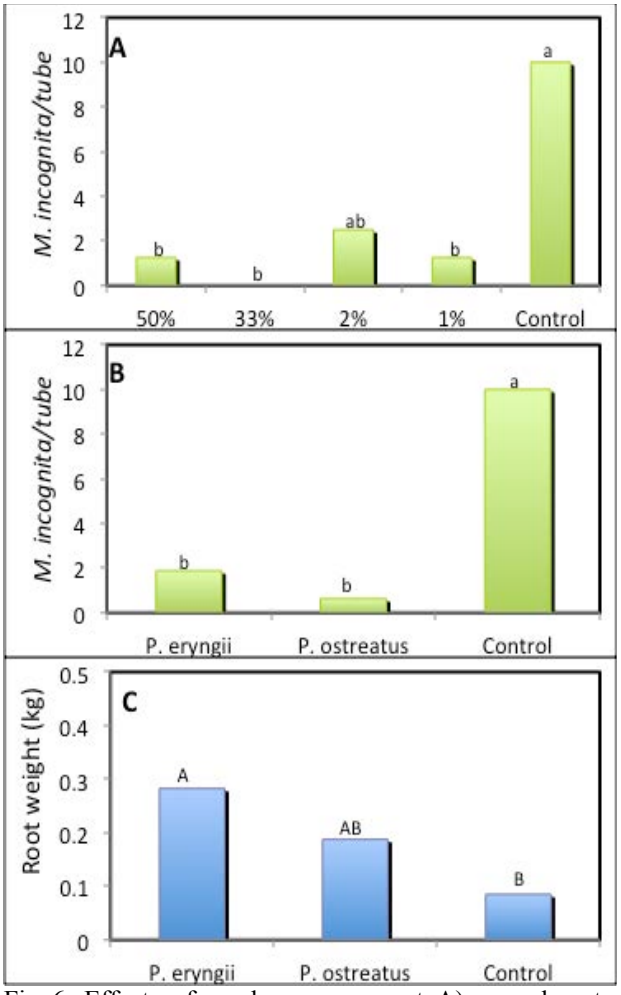

Fig 6. Effects of mushroom compost A) amendment rate, and B) species choices 'Gray Oyster' (*Pleurotus ostreatus*) and 'Ali'i' (*P. eryngii*)) on viability of root-knot nematodes, and C) species choices on zucchini root weight. Means are average of 4 replications. Columns followed by same letters are not significantly different based on Waller-Duncan *k* ratio (*k*=100) *t*-test.

The results from the mushroom compost water extract suppressed activity of root-knot nematodes at all concentrations tested better than the water control. However, most nematodes recovered after washing in tap water. This result indicated that oyster mushroom compost water extract only possessed a nematostatic or paralyzing effect against root-knot nematodes and do not have a nematicidal effect. Although all concentration of this water extract can paralyze root-knot nematodes more effectively than the water control, majority of the nematodes recovered after

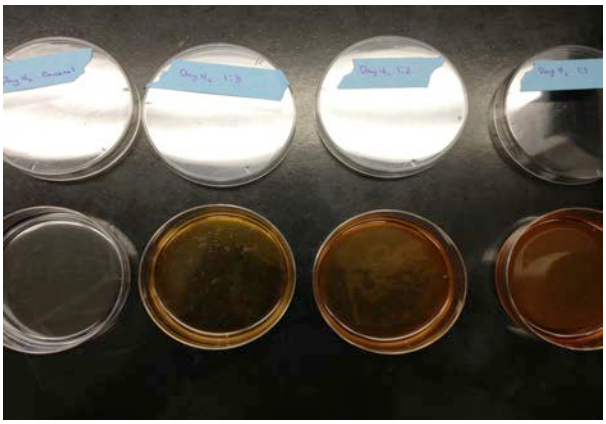

Fig 7. Bioassay for toxicity of mushroom compost water extracts against root-knot nematodes in petri dishes.

rinsing off by water. Only the 50% water extract was best at paralyzing nematodes two days after incubation. The 25% water extract suppressed activity of 40% of the *M. incognita*. This showed the potential of using mushroom compost water extract as a post-plant drenching to suppress *M. incognita* if the toxin is not washed away for 2 days.

Availability of mushroom compost

Local farmers could obtain oyster mushroom compost through self-cultivation, otherwise, purchase or acquire the compost from local commercial mushroom growers (Fig. 8). It is important to be aware that not all mushroom composts have nematode antagonistic effects. Several mushroom species known to suppress plant-parasitic nematodes beside oyster mushroom included shaggy mushroom (*Coprinus comatus*) (Luo et al. 2007), Shiitake (*Lentinula edodes*) (Mamiya et al., 2005), Nematode murderer (*Nematoctonus concurrens*) (Barron, 1977), and King Stropharia (*Stropharia rugosoannulata*) (Luo et al., 2006). These fungi kill the nematodes using different mechanisms.

Fig. 8. Spent oyster mushroom compost is dispensed from bottle containers and accumulated as mushroom compost, occasionally sold as garden compost.

For home or school gardeners, small-scale oyster mushroom cultivation can be grown using recycled coffee grounds. Research at the University of Guam showed that oyster mushrooms were produced more efficiently on coffee grounds than the other substrates tested (Wall, 2004). Oyster mushroom kits that use recycled coffee grounds as substrate or spawn are also commercially available for purchase. Fig. 9 shows Gray oyster mushrooms being grown indoors using brewed coffee grounds.

Fig 9. Coffee grounds colonized by *Pleurotus ostreatus* in plastic bags. Cotton patch allows for oxygen exchange.

Summary

Oyster mushroom compost waste provides promising results in suppressing root-knot nematodes in media with high organic matter but not in those with low organic matter. This implies that oyster mushroom compost should be used as amendment for transplant media mix, let establish for at least 7 days prior to transplanting into the field. Although it does not suppress root-knot nematodes from penetrating into zucchini roots, amending the organic media at ≥ 1% oyster mushroom compost suppressed *M. incognita* introduced to the media. Amending the media with ≥ 2% of mushroom compost could further increase root growth especially if using *P. eryngii* compost. Mushroom compost water extract at 25% concentration paralyzed approximately 40% of nematodes and could be used as a post-plant nematode management option if it is not rinsed out by irrigation for at least two days. Repeated drenching might be needed for long-term nematode control.

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References

Barron, G.L. 1977. The Nematode Destroying Fungi. Canadian Biological Publications Ltd., Guelph, Ontario, Canada. 108.

Barron, G.L. and Thorn R.G., 1987. Destruction of nematodes by species of *Pleurotus*. Can. J. Bot. 65: 774-778.

Kwok, O.C.H, Plattner, R., Weisleder, D., and Wicklow, D.T. 1992. A nematicidal toxin from *Pleurotus ostreatus* NRRL 3526. Journal of Chemical Ecology. 18 (2): 127-136.

Luo, H., Li, X., Li, G., Pan, Y., and Zhang, K. 2006. Acanthocytes of *Stropharia rugosoannulata* function as a nematode-attacking device. Applied and Environmental Microbiology 72 (4): 2982-2987.

Luo, H., Liu, Y., Fang, L., Li, X., Tang, N., and Zhang, K. 2007. *Coprinus comatus* damages nematode cuticles mechanically with spiny balls and produces potent toxins to immobilize nematodes. Applied and Environmental Microbiology 73 (12): 3916-3923.

Mamiya, Y., Hiratsuka, M., and Murata, M. 2005. Ability of wood-decay fungi to prey on the pinewood nematode, *Bursapelenchus xylophilus* (Steiner and Buhrer) Nickle. Japanese Journal of Nematology 35 (1): 21-30.

Marrush, M. 2007. Peat moss fact sheet. UC Davis. <http://afghanag.ucdavis.edu/natural-resource-management/soil-topics/soil-fact-sheets/FS_Growing_Media_Peat.doc>

McClellan, T., Deenik, J., and Singleton, P. 2007. Soil nutrient management for Maui county. University of Hawaii Manoa CTAHR. <http://www.ctahr.hawaii.edu/mauisoil/Default.aspx>

McSorley, R. and Frederick, J. 1998. Extraction efficiency of *Belonolaimus longicaudatus* from sandy soil. Journal of Nematology 23(4): 511-518.

Oka, Y. 2010. Mechanisms of nematode suppression by organic amendments- A review. Applied Soil Ecology. 44. 101-115.

Palizi, P., Goltapeh, M., Pourjam, E., and Safaie, N. 2009. Potential of oyster mushrooms for the biocontrol of sugar beet nematode (*Heterodera schachtii*). Journal of Plant Protection Research. 49 (1): 27-33.

Schmitt, D.P. and Sipes, B.S. 1998. Plant-parasitic nematodes and their management. CTAHR Cooperative Extension Service, University of Hawaii, PD 15. 4 pp.

Wall, G. 2004. Commercial production of tropical mushrooms grown organically. Project Report. Sustainable Agriculture Research and Education. Project number SW01-017. <http://mysare.sare.org/mySARE/ProjectReport.aspx?do=viewRept&pn=SW01-017&y=2004&t=1>

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