Life Soils and Harvest Quest commissioned the University of Florida (UF) to conduct experiments comparing turf grown with Comand® vs. peat moss to determine if the Comand® product has an effect on suppressing nematodes.

A blend of 85% sand and 15% Canadian peat moss is typically utilized for the construction of golf courses and sports fields. Comand® is utilized in place of the peat moss and provides organic matter, similar moisture holding properties, and both accelerated and enhanced grow-in and root development.

The experiments were conducted in micro-plots, which consisted of 8 inch diameter x 18 inch long PVC pipes buried in the ground. The micro-plots originally contained 12 inches of native soil on top of 6 inches of gravel.

In each micro-plot the top 8 inches of native soil was removed and replaced with one of the three following sand blends (construction mixes):
85/15 sand/Canadian Peat
80/20 sand/Comand®
60/40 sand/Comand®

There were five replications of each blend and the experiment commenced in August of 2015. After the amendments were installed, the micro-plots were sprigged with Tifway bermudagrass. Once roots became established, 250 sting nematodes (*Belonolaimus longicaudatus*) were introduced into each micro-plot.

An organic slow-release fertilizer manufactured by GreenEdge® was chosen due to its non-toxicity to the beneficial microbes in the Comand. The fertilizer was applied at the same rate to all the plots and application frequency was based on a typical nutrient requirement schedule determined and utilized by UF staff.

Nematode population density, root length and mass were measured in February and August 2016. A subsequent sample was taken in February 2017 (18 month mark). A single core (1.5 inch diameter) was taken from each micro-plot to the depth of the amendment (8 inches). Nematodes and roots were extracted from these cores and measured. Water infiltration rate was also be measured.

Interim Results

From: "Crow,William T" <wtcr@ufl.edu> **Date:** February 10, 2016 at 4:50:50 PM EST **To:** "Ryan McMeekin (ryan@lifesoils.net)" <ryan@lifesoils.net> **Subject: UF Comand Study**

Ryan, I just analyzed the nematode and root data collected this week.

During grow-in the Tifway bermudagrass sprigs filled in much faster in soil amended with either 20% or 40% Comand Compost than in soil amended with 15% peat.

Six months after sprigging we collected soil and roots samples for analysis and found that root lengths in soil amended with 20% or 40% Comand Compost were 55% and 80% greater, respectively, than in soil amended with 15% peat. Finally, sting nematode population densities were 89% lower in soil amended with either 20% or 40% Comand Compost than in soil amended with 15% peat.

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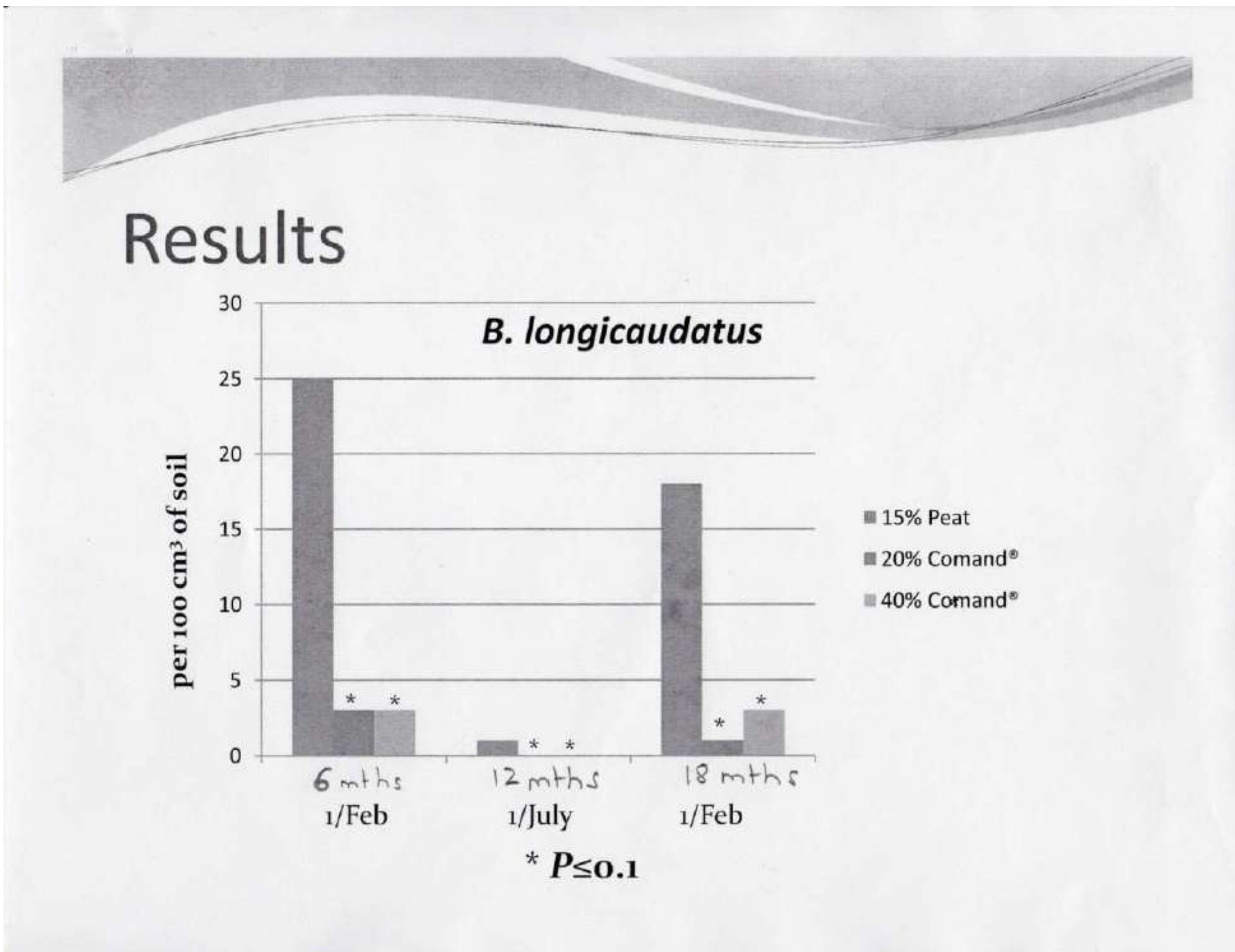
At 12 months, sting nematode population densities were 95% lower in soil amended with either 20% or 40% Comand



At 18 months there was still a highly significant difference

One of Dr. Crow's many tweets:

Several other studies are being conducted at UF's turfgrass research facility in Citra. These include topdressing to measure the effects on nematodes, a larger grow-in study, and potential for thatch reduction.

We are about to scale-up and replicate the micro-plot trial – commencing this week (August 2017). The intent is to use Canadian Peat, Dakota Peat, Comand, and conventional compost all at 80(sand):20 ratios (v:v). Micro-plots are several times larger and overhead images will be taken weekly to document grow-in speeds and canopy density. Nematode counts, as well as, root densities and lengths will again be measured. The end game here is for Dr. Crow to publish a research paper.

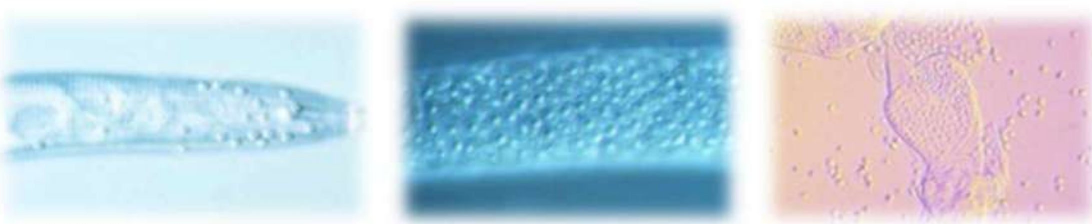
ORIGINAL MICROPLOT TRIALS (U=Peat, 20=20% Comand, 40=40% Comand)

Disease Suppression

Disease incidence in turfgrass can potentially be influenced by the level and type of organic matter and biology present in the rootzone

Certain microorganisms help suppress specific plant diseases as well as being antagonistic to nematodes

- ✓ Actinomycetes populate the soil and outer surfaces of plant roots, driving off parasitic fungi and other soil-borne pathogens
- ✓ They are antagonistic to plant-parasitic nematodes and inhibit egg hatch and/or penetration of roots
- ✓ Pasteuria spp. are endospore-forming Actinomycetes, which are parasites of invertebrates, including nematodes



Pasteuria spores in nematode resulting in rupture

13% of the total fungi population in COMAND has been shown to be species in the *Orbiliomycetes* family.
Several species are carnivorous fungi, and possess a number of specialized mechanisms to trap nematodes
Shortly after coming into contact with its prey, fungal mycelia penetrate the nematode and spontaneously differentiate into functional structures, known as traps, which will ultimately digest the nematode's internal contents

Disease Suppression Mechanisms

- **Antagonism –** some beneficial microbes produce antibiotics which can kill pathogenic organisms and inhibit egg hatch of nematodes

- **Direct Competition –** pathogenic organisms are poor competitors when compared to beneficial microbes, which rapidly populate the soil and overwhelm disease causing organisms by consuming nutrients, energy, oxygen and competing for space

- **Competition for root colonization** - some beneficial microbes have the ability to colonize the surface of plant roots; protecting them from pathogenic organisms. Actinomycetes degrade root exudates that nematodes rely on for root location and to stimulate egg hatch

- **Induction of systemic acquired resistance (SAR) –** a mechanism whereby disease-repressive genes in the plants are activated enabling the plant to better fend off disease causing organisms

Thatch Reduction

Actinomycetes and fungi induce the breakdown of the turf's thatch layer
Thatch restricts the percolation of water and movement of air and coupled with compaction, can result in anaerobic conditions, leading to very shallow root systems, drought stresses, and disease pressures

- Thatch is 'organic material' (largely undecomposed), whereas
- COMAND is 'organic matter' (decomposed and stabilized)

In practical terms, the degradation of thatch and its conversion to humus (organic matter) and humic compounds (plant food) provides the turf manager with a host of practical benefits, potentially saving work time and costs whilst improving the playing surface.

A golf green is basically a sand-based artificial environment (soil-less) and largely devoid of beneficial microorganisms. Because there is limited biology, grass clippings and dead roots etc. do not fully decompose and result in a buildup of organics (Thatch).
Comand however, is a biologically active material and its introduction into ultra dwarf greens supplies beneficial fungi and bacteria, which convert (decompose) thatch into humus. Think of it as an inoculation.
Thatch forms a layer in the upper root zone and restricts the percolation of water and movement of air. This coupled with compaction of the sand, results in anaerobic conditions, leading to very shallow root systems, drought stresses, and disease pressures.
The addition of sand to the rootzone, through core aerification, to dilute Thatch is common practice. Thatch is mostly lignin, which is consumed (broken down) by fungi and Actinomycetes. Without fungi, dilution with sand will have a very limited effect.

The difference between Thatch and the organic matter contained in Comand, is the fact that the Comand product has been subjected to highly active decomposition over several months and is stabilized and mineralized. It contains billions of microorganisms and all they want to do is eat. Thatch is the all you can eat buffet and assuming no harsh fungicides are utilized following Comand's application, the Thatch will be converted to humus and plant food.
Strictly speaking, Thatch is 'organic material' (largely undecomposed), whereas Comand is 'organic matter' (decomposed, stabilized and mineralized).

The organic matter in Comand, unlike the organic material contributing to Thatch, actually improves the structure and percolation rate of a golf green

Organic matter plays a key role in the structural stability of the rootzone. A rootzone without organic matter compacts very easily and suffers from poor aggregation. Conversely, healthy soil maintains pore spaces and has much improved oxygen transfer and water infiltration rates.
Bacteria and fungi produce polysaccharides to help them adhere to surfaces and to prevent them from drying out. The polysaccharides are sticky substances, which clump fine sand particles together, forming air space in between.
Organic matter also retains moisture in times of drought. Roots grow in the spaces between soil particles, which further enhances the physical benefits of correct organic matter content.
In practical terms, the degradation of thatch (organic material) and its conversion to humus (organic matter) and humic compounds provides the turf manager with a host of practical benefits, saving work time and costs whilst improving the playing surface.

Microbiology Of Comand

Bacteria (Order)	%
actinomycetales	23.83899138
clostridiales	13.36919014
gemmatimonadales	10.98837546
bacillales	8.00994737
sphaerobacterales	6.74435641
xanthomonadales	4.90717714
bacteroidetes order ii. incertae sedis	3.52977464
chromatiales	3.18277331
sphingobacteriales	2.17454167
thermomicrobiales	1.54319203
acidimicrobiales	1.33884680
anaerolineales	1.12968211
cytophagales	1.08630694
pseudomonadales	0.86075608
acidithiobacillales	1.04582345
phycisphaerales	0.81448923
thermoanaerobacterales	0.81256145
rhodocyclales	0.59183005
rhodospirillales	0.44724616
desulfuromonadales	0.41158213
thermodesulfobacteriales	0.36049583
planctomycetales	0.35953193
chloroflexales	0.31326509
rubrobacterales	0.29591502
burkholderiales	0.27181771
thermales	0.26410657
flavobacteriales	0.26314268
chlorobiales	0.23229811
sphingomonadales	0.20723691
thermoleophilales	0.20627301
ignavibacteriales	0.20434523
verrucomicrobiales	0.16386174
enterobacteriales	0.16193395
desulfovibrionales	0.15229503
nitriliruptorales	0.14747557
opitutales	0.10795597
solirubrobacterales	0.07711141
holophagales	0.06843637

thermolithobacterales	0.06361691
methylophilales	0.05976134
bdellovibrionales	0.05879745
candidatus brocadiales	0.03566403
bacteroidales	0.03277235
bacteria	0.03277235
rickettsiales	0.02506121
methylococcales	0.01927785
lactobacillales	0.01542228
syntrophobacterales	0.01349450
natranaerobiales	0.01253060
acidobacteria	0.01060282
desulfobacterales	0.00963893
chlamydiales	0.00867503
chroococcales	0.00867503
legionellales	0.00771114
spartobacteria	0.00674725
vibrionales	0.00674725
thiotrichales	0.00674725
desulfurellales	0.00578336
hydrogenophilales	0.00578336
thermoflexales	0.00481946
dehalococcoidia	0.00289168
nitrospirales	0.00289168
oscillatoriales	0.00289168
deinococcales	0.00192779
solibacterales	0.00192779
gloeobacterales	0.00096389
acholeplasmatales	0.00096389
fibrobacterales	0.00096389
magnetococcales	0.00674725
spirochaetales	0.00385557
gaiellales	0.00385557
firmicutes	0.00289168
prochlorales	0.00192779
aquificales	0.00192779

Actinomycetes are of great benefit and populate the soil and outer surfaces of plant roots, driving off parasitic fungi and other soil-borne pathogens. The area, which includes the root zone and the soil closely associated with it, is known as the "Rhizosphere". These rhizosphere - inhabiting bacteria are antagonistic to plant-parasitic nematodes and inhibit egg hatch and/or penetration of roots.

The mechanisms by which antagonistic bacteria inhibit plant-parasitic nematodes include:

1. Production of antibiotics that kill nematode eggs
2. Degradation of the root exudates that the nematode relies on for location and to stimulate egg hatch
3. Induction of systemic acquired resistance (SAR).

Pasteuria spp. are endospore-forming Actinomycetes, which are parasites of invertebrates, including nematodes. Spores of these species adhere to the cuticle of the host nematodes that encounter them while moving through the soil. The bacteria's life cycle occurs within the nematode - from spores to bacteria to spores again. The bacteria multiply within the nematode eventually causing death.

Fungi (Class)	%
eurotiomycetes	41.38796895
sordariomycetes	36.45840537
orbiliomycetes	13.10352814
basidiomycota	6.29687818
agaricomycetes	0.87692196
pezizomycetes	0.80855623
dothideomycetes	0.70337819
leotiomycetes	0.47067176
glomeromycetes	0.19786620
agaricostilbomycetes	0.13081520
eukaryota	0.10517805
tremellomycetes	0.10320596
saccharomycetes	0.05784793
mortierellomycotina	0.04009913
anthozoa	0.03615495
insecta	0.03484023
aconoidasida	0.02235033
microbotryomycetes	0.01380462
chytridiomycetes	0.01248989
mucoromycotina	0.01183253
bryopsida	0.00854572
liliopsida	0.00788835
bivalvia	0.00723099
ichthyosporea	0.00723099
dinophyceae	0.00460154
cryptomycota	0.00460154
basidiobolomycetes	0.00460154
ascomycota	0.00328681
coniocybomycetes	0.00328681
hydrozoa	0.00328681
exobasidiomycetes	0.00262945
blastocladiomycetes	0.00262945

coccidia	0.00197209
xanthophyceae	0.00197209
lecanoromycetes	0.00131473
chlorophyceae	0.00065736
cystobasidiomycetes	0.00065736

Orbiliomycetes are a class of fungi in the Ascomycota. It includes the single order Orbiliales, which in turn includes the single family Orbiliaceae.

The Orbiliaceae are a family of saprobic sac fungi in the order Orbiliales. The family contains 288 species in 12 genera. Members of this family have a widespread distribution, but are more prevalent in temperate regions. Some species in the Orbiliaceae are carnivorous fungi, and have evolved a number of specialized mechanisms to trap nematodes.

This family is well known for its many nematophagous species. Shortly after coming into contact with its prey, fungal mycelia penetrate the nematode and spontaneously differentiate into functional structures, known as traps, which will ultimately digest the nematode's internal contents. There are 5 types of trap mechanisms recognized in this family:

- Adhesive network: the most common trap, formed by hyphal outgrowths that recurve into themselves to form nematode-trapping loops.
- Adhesive knob: a roughly spherical cell, attached to the hyphae either directly or on an erect stalk. Adhesive knobs are typically closely spaced along a section of hyphae.
- Nonconstricting rings: always found with the adhesive network traps, and formed from thickening hyphae that curve and fuse to the supporting stalk.
- Adhesive column: a layer of cells on a hyphae with an adhesive surface.

Constricting rings: these are rings of hyphae that swell rapidly inwards upon contact with the nematode, quickly (in 1–2 seconds) "lassoing" the victim.

Most **trapping fungi** can proliferate in soil in the absence of nematodes, meaning a resident population can exist even after nematodes have been killed off. Therefore, future infestations can be prevented.

Through the utilization of DNA extraction techniques and gene-sequencing, we are aware that Comand contains several thousand species of bacteria and fungi and that these populations can be influenced through various production and re-inoculation techniques