Observed Effects of Row Coverings on Temperature, Humidity and Fruitbody Moisture Content

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As the title of my talk suggests these are indeed "observations." Joe (Krawczyk) and I have noticed for the years that we've been doing this, that there are a lot of differences between mushrooms growing underneath fruiting/humidity blankets and we really wanted to put this to the test. We started this experiment about August. After going through several replications to try to iron out the technical problems, snow started looming on the horizon about early September so we couldn't do a full-blown experiment this summer/fall. So these are really just observations, it's sort of a "pilot-study," if you will, we didn't run any statistics because we didn't have the proper number of replicates.

THESE ARE COVERINGS WE USE TO COVER PILES OF LOGS AFTER THEY COME OUT OF THE SOAK TANK

What are fruiting blankets? Well we've known them as "humidity blankets" and "fruiting blankets"—these are coverings we use to cover piles of logs after they come out of the soak tank. They provide a nice environment to promote and establish healthy fruiting. Fruiting blankets can also be used for a number of other purposes, but this talk today is focused on the effects of fruiting blankets on mushroom production.

Fruiting blankets have been around for a long time. They have also been established nationwide—we've seen them everywhere we've gone. They don't always have to be made out of fabric. In our climate we have very dry springs and quite chilly falls. In the earlier days, when we didn't have a lot of fruiting blankets on hand, we used pine boughs from thinnings of white pines. What does a fruiting blanket actually do? One thing we know for sure is that it tends to still the wind speed around the actual log as they're pinning and fruiting—creating a more humid environment for the mushrooms as they're coming forth. So you can use some locally available materials.

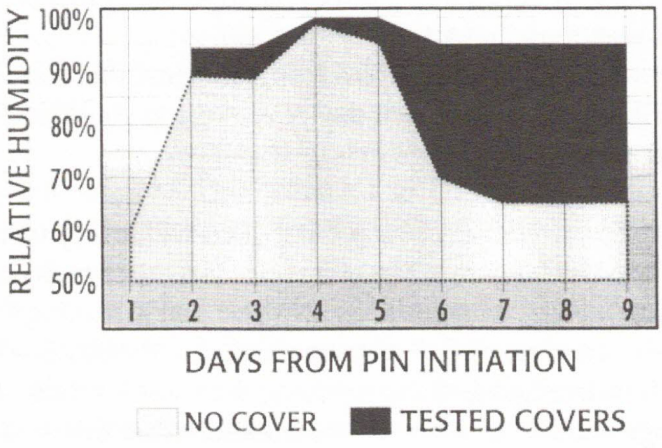
If you don't have a lot of thinnings of white pines in your laying yard, you can use other materials, they don't have to be a "fruiting blanket." We've seen burlap, plastic, garden fabrics, and many other things used in this capacity. So what we wanted to do—since we sell a fruiting blanket—was start comparing the differences between some of these materials. For a small (or large) grower on a limited budget we want to see what we've got on hand that might be cheaper and more available. We then walked out into the laying yard and selected logs all of the same age, inoculated with the same strain, and we took those logs and soaked them. As they were coming out of the soaking tank we selected logs that were approximately 4" in diameter and 40 inches in length. We stacked them in separate piles: 15 logs per pile. Then we covered the piles with different fabrics that we've seen used quite frequently.

The first thing we did was not cover a pile so that we could always check against an uncovered pile which we refer to as the "no cover." We also used 4 mil clear plastic which is what you typically find in a building supply store—it's widely available. Another thing we used is "Reemay®"—those of you who are gardeners may be familiar with this fabric—it's a floating, both white and black, row cover that is often used in strawberry production and gardening. It's one of the lighter fabrics—we use two layers—one layer is not enough and it's generally available. The other two things we used are geotextiles and that's what our "fruiting blanket" is. In the past, we always used a white fruiting blanket which we got from a geotextile company. We're also trying to locate some papermill felt—we haven't found any yet but there are a number of paper mills in our area—it's probably quite similar. Then about 6 years ago they stopped making a white one—we always wanted to use the white one because we thought it would be better because it would reflect sunlight so we figured we wouldn't gain as much heat. But we can't get the white one anymore—it's only available in black so we thought we should see if there was a difference between the white one and the black one.

We tried to try to quantify some of this information—to see if we could put some actual numbers to what was going on underneath these materials. To do that, we measured temperature and humidity. We measured both the daytime highs and the nighttime lows under each treatment. We also measured the humidity prior to 7 a.m and 3 p.m. To do that we used a hygrothermograph which measures humidity and temperature at the same time.

The relative humidity from the day that we took the logs out of the soaking tank toward the end of harvest shows that when the logs came right out of the tank there was very little difference—the relative humidity was really quite high for the first day or two. One could surmise that maybe that's just because the logs were wet and with or without coverings a lot of humidity was being generated from the drying logs. Then about day 3-5 it was raining so there really wasn't a lot of difference between "no cover" versus all the logs that were covered. But as we proceeded to day 8-9 we got dryer/cooler weather and then we noticed a really big difference. What we found is that it stayed very humid underneath the covers when compared with the uncovered pile—that's fairly predictable.

Relative Humidity Comparison



BIG DIFFERENCE IN THE DAYTIME HIGHS AND NIGHTTIME LOWS IN THE UNCOVERED PILE

The daily temperature range during the same time period—from the day the logs came out of the soak tank to the 8-9 days later—reflected outdoor environmental conditions. To help explain what happened, I felt we had to discuss what was going on in the weather. The first day it was sunny then it got cloudy and rainy then stayed cloudy and cool. We only had one day of sun. The "no cover" pile and those logs which were underneath the clear plastic showed the largest gain in temperature. Whereas all of those logs underneath covers were quite moderate in terms of temperature change. So there was a big difference in the daytime highs and nighttime lows in the uncovered pile and the logs covered with clear plastic when it was sunny and warm. There was less of a difference as we proceeded into the rainy time. In fact there's not a lot of difference between any of the covered piles. When we get to the cloudy cool weather we notice one thing in particular and that is that the "no cover" has a greater range between daytime highs and nighttime lows. Coverings, then, tend to moderate temperature—unless it's sunny out.

WERE THESE COVERINGS REALLY CHANGING THE YIELDS AT ALL?

Another thing we wanted to know was, "Were these coverings really changing the yields at all?" All the covered treatment yields are very close to each other but the no cover treatment has a higher yield. The third time we did this experiment, the "no cover" treatment was very high, but the two prior times yields were much lower. That tells me that with the no cover treatment there is a big range of variability. We also measured the moisture content of these mushrooms because we wanted to make sure that wasn't influencing the yield, especially with the no cover versus the others. We found that they were all very close.

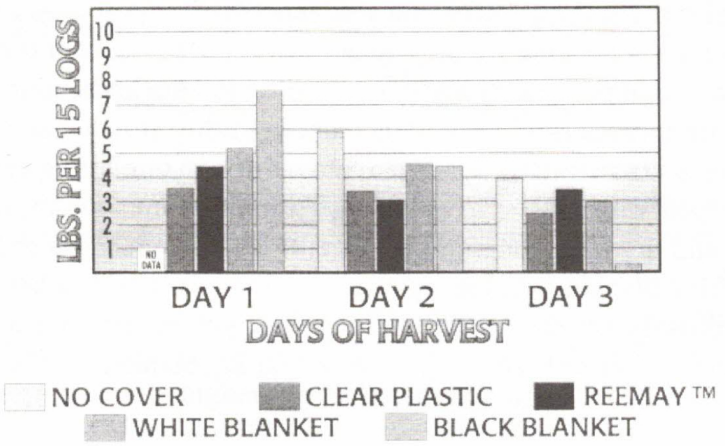
Average Yields Using Multiple Covering Materials

Cover Type	*Lbs./Log*	*% MC*
No Cover	0.74	91%
Clear Plastic	0.63	91%
Reemay®	0.60	91%
White Fruiting Blanket	0.65	92%
Black Fruiting Blanket	0.70	91%

We looked at the mushroom pinning stage to see if there were any differences in the mushrooms actually coming out of the logs. What was consistent all three times we did this was found under the black fruiting blanket. Underneath the black fruiting blanket we had these big white blobs of stems that looked like it was developing faster. So we measured each day of harvest to find out if the rate of development differed between coverings.

What we found was: Day 1—we got yield with every treatment with the exception of the "no cover" treatment. You'll notice that the pounds per log really increased with the black fruiting blanket. Day 2—The black fruiting blanket yield went down slightly and the "no cover" went up quite a bit. By Day 3—The black fruiting blanket was nearly finished and the no cover was still fruiting heavily and the other two coverings were somewhere in the middle. What this said to us was that the black fruiting blanket brought on fruiting at least one full day earlier than the no cover and

approximately half a day earlier—yield wise—compared to the other blankets. Now you may say, "Oh, big deal," but for us, if for some reason we don't soak logs on time, or we get cool weather or whatever—that one extra day can really make a big difference whether or not we can ship all the mushrooms we need for that day.



Daily Yields Correlated to Row Cover Materials

Now, one might ask, "If there was no temperature difference between highs and lows for the black fruiting blanket compared to the others, why, in fact, would you get earlier fruiting?" We did measure daytime highs and nighttime lows but not how long those temperatures were at that level. I would propose to you that the temperature may have held for a longer period of time with the black fruiting blanket than with the others.

Cover Type	*Cost in $*
No Cover	n/c
Clear Plastic	0.02
Reemay®	0.10
White Fruiting Blanket	n/c
Black Fruiting Blanket	0.14

Comparative Cost of Row Cover Materials

COMPARATIVE COSTS

One might be interested in the comparative costs of these materials: No cover obviously costs nothing; clear plastic costs .02 cents per sq. ft.; Reemay® is .05 per sq. ft. but we're using two layers so that will be .10 sq. ft.; and the white and black fruiting blankets cost the same at .14 per sq. ft. So you think, "Is it worth it to spend this much money on these fruiting blankets?" We have some customers who use various covers and different people have different opinions. One woman I spoke with said she would never consider using plastic—the mushrooms sweat and get a lot of bacterial pitting—of course it's very warm where her farm is located. She also worries about fruiting blankets because they're very hairy—you get hairs on the mushrooms and chefs and buyers may object to that. With the Reemay®—she's gone to a 3-layer Reemay® that's one of the thicker Reemay® too, because in their system, they're always watering, everything is on timers and the sprinklers don't care whether there is fruiting going on so they have to cover the fruiting piles—using three layers can

increase the cost even more. So to answer the question of "Is it worth it?" It depends on your system and what you've got available.

FRUITING BLANKET CAN BE USED FOR MORE THAN JUST FRUITING

I do want to point out another thing: The fruiting blanket can be used for more than just fruiting—and this is not just a pitch for fruiting blankets—this is just the way I see it. These blankets are durable, they can be used for covering piles after the logs are cut to avoid sun exposure before they're inoculated. After logs are inoculated some folks dead-stack logs before they're put out to the permanent laying-yard and they're covered at that point with a blanket. During dry spells fruiting blankets can be wet-down with sprinklers which will increase humidity around the logs during the laying-time. We get tremendous winds that blow through our laying yards so we use the blankets tarped with plastic to encourage a moister mushroom, otherwise the mushrooms would dry up in the pinning stage. If it's dry while we're fruiting we'll just put the fruiting blanket over the logs and water the fruiting blanket so you're not getting water directly on the mushroom caps but you're creating a more humid environment on the fruiting blanket itself. Also fruiting blankets can be used as wind breaks.

You can't walk through our laying yard on a summer day without seeing fruiting blankets all over the place. We really like them but I would think a lot more carefully about using plastic more. Especially in our climate—in cooler weather—I think plastic is a valuable, cheap material to use.

This is what we can conclude from our results: Fruiting blankets increase humidity; fruiting blankets moderate temperature; yields may be variable with no fruiting blanket; black fruiting blankets may encourage earlier picking. Things that this didn't exactly point out but that we know include: We have to have fruiting blankets in the spring when we get a lot of wind and we don't have proper leaf/tree cover and we must have them during really rainy periods to shed water from the mushrooms. We didn't actually show many numbers but a lot of times we were just talking about differences of 2-4% relative humidity or 2-4 degrees and we saw, what I thought to be, pretty big differences and I think that goes to show the importance of micro-climate.

QUESTIONS AND ANSWERS:

Q. *Did you find the fruiting blankets encouraged any other fungi on your logs like Trichoderma? Especially when you were using them for cover rather than fruiting?*

A. Certainly doing this experiment we haven't. But at one point we did an experiment where we mulched with straw and covered with plastic to create a very humid environment and we had a lot of problems with that, so I would proceed with caution especially in the more humid areas.