Improving the yield of cold-weather shiitake by irrigation

Final report for FNE16-860

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Project Leader:

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Project Information

Summary:

Cold weather strains of shiitake which fruit naturally and do not require soaking present advantages to small-scale producers. Typical cultivation techniques allow logs to remain stacked in one place for their useful life of 4-7 years, requiring less infrastructure and labor, reduced log damage from repeated handling, and, due to the time of year of fruiting, less slug and insect damage. Our study looked at three harvest periods where we have trialed using irrigation at a very early stage of fruiting to find out whether the timing of fruiting can be manipulated to allow more effective harvest, balancing this with the knowledge that irrigation too late in the fruiting process may lead to crop losses as mushrooms soak up excess water.

In 2017, one irrigated log produced over 2lbs of shiitake, however most of the irrigated logs produced around 0.5lb, with non-irrigated logs producing around 0.25lb of saleable mushrooms. Over the course of the study, average yield from irrigated logs was almost double that of non-irrigated logs, across all tree species - irrigated beech produced 38lbs in total compared to 18 for non-irrigated, irrigated oak 33lbs compared to 14lbs non-irrigated, and irrigated maple 34lbs compared to 15lbs for non-irrigated. However, caution should be applied when interpreting these results: the yields were small overall, and the increased yield from irrigated logs can be almost entirely attributed to the prevention of losses of fruit in very dry and windy conditions rather than through the encouraging additional fruiting on the logs, hence our conclusion that irrigation can play a more important role in protecting harvests than in triggering the fruiting response in logs.

Main Findings

- irrigation does not effectively stimulate fuller fruiting on cold weather logs
- there may be some encouragement of fruiting on smaller logs but this is marginal
- there was no observable difference between tree species or CW stains regarding

their response to irrigation

- however irrigation does improve the quality (both in terms of size of individual mushrooms and their texture, density and visual appeal) of mushrooms particularly when used in conjunction with shade cloth and fruiting blankets. The differences are particularly noticeable when it is dry and/or windy and irrigation has potential to save crops in these conditions.

The findings of the study have been published on Philo Woodland Farm's website: http://philowoodlandfarm.weebly.com/cold-weather-research, and results have been circulated among the UVM mushroom growers listserv, reaching approximately 200 mushroom growers. Presentations have also been made to the Northeast Organic Farming Association's Winter Conference, to the Montgomery Conservation Commission, and at four mushroom growing classes at Champlain Valley Union Access program, totaling around 120 audience members.

Project Objectives:

We sought to find out how water availability in the very early stages of fruiting affects the production of cold weather strains of shiitake. Specifically, by providing targeted irrigation, using different flow rates and water volumes to logs of different tree species inoculated with different shiitake strains we sought to find out whether the timing of fruiting can be manipulated so that harvest can be carried out more effectively, so lowering the risk of stunted growth, predation, and frost damage. We measured and compared production (both quantity and quality) from logs irrigated under different regimes with existing production logs, and then with newly inoculated logs made a comparison to see if different tree species and shiitake strains respond differently to irrigation.

Introduction:

Log-grown shiitake are an increasingly popular and potentially valuable agro-forestry crop for small-scale farmers, and a recent SARE project (2014-2015 Market Assessment on Forest-Grown Shiitakes in the Northeast) notes that almost 60,000 logs will be in production in 2018, providing farmers with a combined income of up to $950,000 annually.

In the North East, wide range (WR) strains of shiitake are typically cultivated on oak, maple or beech logs. During the fruiting season (May-October) logs are soaked in cold water every 7-8 weeks for 21-24 hours to force fruiting. This cycle provides regular harvests throughout the summer, and at a small scale requires little infrastructure and only moderate ongoing management.

However scaling up this method of cultivation is more difficult, as the need to move, store and soak hundreds or thousands of logs requires space and investment in machinery and or labor. The use of cold weather (CW) shiitake strains has been pursued by a number of producers to provide a low labor, low infrastructure method which is much easier to scale up.

Cultivation of CW strains allows logs to remain stacked in one place for their useful life of 4-7 years, requiring less infrastructure and labor. Additional benefits of CW varieties are that fruits tend to be larger, of higher quality, and store well, thus commanding higher retail and wholesale prices.

The main drawback of cultivating CW strains is the reliance on natural environmental conditions to stimulate fruiting. Under favorable environmental conditions, CW strains produce at least as much fruit as typically grown WR strains, and a much higher quality crop.

Fruiting of these strains is triggered by temperature, and under optimal conditions logs produce very high quality mushrooms. However when temperatures are in the correct range but humidity is very low or there are drying winds, fruiting is sporadic, requiring multiple small harvests from each log, increasing the risk of predator damage, stunting fruit growth and compromising fruit quality.

Philo Woodland Farm has grown shiitake for 8 years, and in recent years has focused on CW strains. When correct “trigger” temperatures coincide with rain or humidity, then the harvest is compressed into a shorter time period, and almost all the caps develop fully. Under dryer conditions a significant proportion of caps do not develop fully or may be delayed so that harvesting may stretch to 3-6 weeks or even longer, as only small numbers of mature mushrooms can be harvested each day. The longer the harvesting period, the lower the overall yield, as mushrooms can be stunted, stop growing at all, or suffer damage from pests. Additionally, longer harvest periods require more labor as each log must be checked multiple times.

Temperature is the main trigger for fruiting CW strains, and when temperatures are 35-50F (in spring and fall), fruiting will naturally occur over a 10-14 day period, during which harvesting is required every 1-2 days. These natural harvests in cooler seasons are less susceptible to damage from slugs and insects

When correct trigger temperatures coincide with light rain or humidity, then the harvest is compressed into a shorter time period, and almost all the fruit caps develop fully. Under dry conditions a significant proportion of caps do not develop fully or may be delayed so that harvesting on a single log may stretch to 3 or 4 weeks or more.

The longer the harvesting period, the lower the overall yield as mushrooms can be stunted, stop growing at all, or suffer damage from pests. In worst cases yields may be reduced by 50% or more.

The focus of shiitake research in the US, and particularly the North East has been to develop good practice for log based operations to maximize yields and to help develop and strengthen markets for log-grown shiitake. This work has been successful and there is an increasing number of farmers and growing demand and appreciation for log-grown local shiitake. The majority of shiitake grown in the North East are wide range strains, force fruited in the summer by smaller producers as an additional niche crop for farmers markets. Hence research has focused on tree species and harvesting and management cycles which include soaking, fruiting and resting periods.

Most guides to shiitake cultivation mention that irrigation of logs can help promote initial colonization by mycelium, and stress the need to ensure logs do not dry out completely during their whole lifetime, but the focus is on the internal moisture level of logs. We have found no studies into the effect of external moisture levels on fruiting characteristics of cold wather strains.

Cooperators

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Research

Materials and methods:

In Spring 2016, we mad a new laying yard set up and 270 logs were inoculated with cold weather shiitake, consisting of three groups of 90 logs (beech, oak and maple). Each group was further divided into three and inoculated with 3 different CW strains - Bellweather, Miss Happiness and Snowcap. Logs were an average of 4 feet in length and 6 inches in Diameter.

In Summer 2016 a new laying yard was designed & constructed. The aim was to develop a system that can be replicated in a variety of locations, including remote areas, in keeping with the low-tech nature of cold weather shiitake cultivation, the system was very simple but effective.

Irrigation options were researched and discussed with the project adviser, and a system installed consisting of a single irrigation line feeding sprinklers from 1/2 inch hose with 300gph, gravity fed from 2 shallow wells and a group of four 285 gallon storage tanks. Total capacity of the system is around 2500 gallons.

Storage tanks needed to be purchased as the dry winter of 2015/16 showed that the recharge rate of our existing wells was not sufficient to deliver the required flow rate/duration. In 2017 the system had sufficient capacity to deliver the irrigation required.

After sourcing the used 275 gallon totes, the only additional materials were 3 inch to 1/2inch connectors, 1/2 inch hosepipe and a sprinkler head.

A set of older logs inoculated in Spring 2015 was irrigated in October 2016 as a test run for the full irrigation trials. We had mixed results – there was no obvious concentration of fruiting period on the irrigated logs, but the quality and size of fruit was improved. The first irrigation trials were held in Fall 2016, using 200 logs that had been inoculated in 2014 and which had produced an average of .75lb of mushrooms per flush in 2015. When logs began to fruit naturally they were irrigated to try to stimulate a full fruiting on each log. This provided some initial results to compare with non-irrigated logs. Although there was no concentration in the fruiting period and no difference in the number of mushrooms per log, irrigated logs did produce larger and denser fruit which were more marketable.

Visual inspection in Fall 2016 showed very good mycelium colonization across all of these logs. A single irrigation line feeding sprinklers, gravity fed by 2500 gallon storage (shallow wells and poly tanks) was set up.

In Spring 2017 we irrigated the logs during the natural fruiting cycles to encourage fruiting to concentrate over a period of days rather than weeks. Our first natural fruiting of 2017 occurred in April. Shiitake pins were observed on the 18th, and the experiment logs were immediately irrigated for 2 hours and covered with shade cloth to conserve moisture. They were irrigated again for 2 hours the following day. Growth proceeded over the following week. However there was no observable difference in the number of pins on irrigated and control logs, suggesting that irrigation had not encouraged further fruiting. However weather during that week was dry and windy windy and fruits began to dry before forming fully. Further irrigation was carried out three times daily for periods of 10 minutes, and the logs were kept under shade cloth. When harvesting began on 25th April, it was clear that whilst irrigation had not increased the number of individual fruits on logs, the irrigated logs produced larger and better quality fruit, and that fruits on the control logs had dried and stopped growing before being fully formed. One irrigated log produced over 2lbs of shiitake, however most of the irrigated logs produced around 0.5lb, with non-irrigated logs producing around 0.25lb of saleable mushrooms.

At the beginning of October 2017 temperatures dipped and pinning was observed on 10th October. However, high daytime temperatures over the following two weeks including a run of days in the high 70s, led to there being no worthwhile Fall harvest. We irrigated daily for 2 hours but no difference was observed, with just the occasional mushroom fruiting from irrigated and non-irrigated logs. In total the 270 experiment logs produced only 15lbs mushrooms in Fall 2017.

Spring 2018 was our next testing period. We had some very late snow falls and temperatures stayed in the 30s and 40s until 21st April, then rose to the 50s and 60s for one week, jumping to 80F on 2nd May and then remained above 65F. Therefore there was a very short window for fruiting, before high temperatures set in. Regular watering, coupled with shade cloth proved useful in allowing the mushrooms that had fruited to achieve maturity, but yields were again very low - in total 26lbs from 270 logs. It is estimated that only around one third of mushrooms grew to maturity after the spike in temperatures.

Total pounds of mushrooms from irrigated and non-irrigated logs

	Beech		Oak		Maple		Total
	irrigated	Non-irr	irrigated	Non-irr	irrigate	Non-irr	
Spring 2017	28	15	26	10	21	11	111
Fall 2017	3	1	2	2	4	3	15
Spring 2018	7	2	5	2	9	1	26
Total	38	18	33	14	34	15	152

Our best performing irrigated log, spring 2017. This was an anomally: don't expect this yield from average cold weather logs!

Research results and discussion:

The study has shown three main findings:

- irrigation does not effectively stimulate full fruiting on cold weather logs
- there may be some encouragement of fruiting on smaller logs but this is marginal
- however irrigation does improve the quality and size of mushrooms particularly when used in conjunction with shade cloth and fruiting blankets, compared to non irrigated mushrooms. The differences are particularly noticeable in dry conditions. Therefore irrigation has potential to save crops that are at risk from dry and or windy conditions.

Research conclusions:

We met all our project milestones as planned, developing a strongly colonized group of logs to work on, a new area to allow safe and easy movement between log stacks, along with an irrigation line which brings water to the laying yard, using gravity from a well and water storage facility higher up the hill.

Winter 2015/16 was very dry, and our surface wells' water storage was much lower than experienced in previous years. Continuing dry weather through 2016 meant that they never achieved full capacity and is was clear that additional storage capacity was needed. This was been installed and we have sufficient capacity to implement irrigation regimes as planned. This was an important result of the project - realizing how limited our water supply was and increasing storage capacity.

We tested irrigation on a group of 150 logs that were inoculated in 2015, and again on logs inoculated for the purposes of the project. Results of this irrigation were mixed in all cases. The overall period of time taken for a log to fully fruit was not affected, but the quality of fruits grown under irrigation was clearly higher, both in terms of size of individual mushrooms and their texture, density and visual appeal.

In addition irrigation was shown to be able to save a proportion of mushrooms that would have not fully formed due to dry conditions.

The approach taken worked well - we had a well thought out methodology and even though the results were not as anticipated, useful information was gained on stopping mushrooms drying out before fully grown. This has resulted in the saving of a proportion of crops that would have been lost entirely without irrigation.

The project also prompted us to further analyze our on-farm water requirements and existing water availability, requiring us to install additional water storage, and we now have system that will help protect crops during dry conditions.

Participation Summary

1 Farmer participating in research

Education & Outreach Activities and Participation Summary

4 Webinars / talks / presentations

PARTICIPATION SUMMARY:

20 Farmers

Education/outreach description:

Presentations on this project have been made at the NOFA winter conference on February 18th 2018, to the Montgomery Conservation Commission on June 6th 2018, at CVU Access mushroom cultivation classes in November 2017 and February 2018. In addition, a report was prepared and published on the Mushroom listserv group.

Learning Outcomes

1 Farmers reported changes in knowledge, attitudes, skills and/or awareness as a result of their participation

Key areas in which farmers reported changes in knowledge, attitude, skills and/or awareness:

Gained awareness that small amounts of watering fruited logs can improve size, texture and appearance of shiitake

Project Outcomes

1 Farmers changed or adopted a practice

Project outcomes:

The project has shown that while irrigation does not noticeably concentrate the fruiting period of cold weather shiitake, it can improve size and quality of fruit,

particularly during dry and or windy weather, by helping conserve moisture in the fruit, particularly in conjunction with shade cloth and fruiting blankets. Whether or not this will have wide applicability is unknown, but I have circulated results of the project among existing growers, and have presented at the NOFA winter conference, and at mushroom growing classes I have taught, and will continue to ask for feedback on whether other growers have a problem with fruits drying on logs before becoming fully formed.

The summary report and conclusions was published on the my website http://philowoodlandfarm.weebly.com/ and published on the UVM mushroom growers listserv, reaching almost 200 growers.

Assessment of Project Approach and Areas of Further Study:

The approach taken worked well- we had a well thought out methodology and even though the results were not as anticipated, useful information was gained on stopping mushrooms drying out before fully grown. This has resulted in the saving of a proportion of crops that would have been lost entirely without irrigation.

The project made us analyze our on-farm water requirements and existing water availability, requiring us to install additional water storage, so we now have system that will help protect crops during dry conditions.