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Soil Water Monitoring in Below-Ground Ectomycorrhizal Colony of Tricholoma Matsutake

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ABSTRACT

Water is critically important for Tricholoma matsutake(Tm) growth because it is the major component of the mushroom by over 90%. The mushroom absorbs water through the below ground hyphal colony. Therefore, the objectives of our study were to investigate spatio-temporal water changes in Tm colonies.

This study was carried out at Tm fruiting sites in Sogni Mt National Park, where the below-ground mushroom colonies have been irrigated. To identify spatial water status within the Tm soil colony soil moisture and ergosterol content were measured at six positions including a mushroom fruiting position on the line of the colony radius. To investigate temporal soil moisture changes in the soil colony, Time Domain Reflectometry(TDR) sensors were established at the non-colony and colony front edge, and water data were recorded with CR10X data logger from late August to late October.

Before irrigation, whereas it was 12.8% at non-colony, the soil water content within Tm colony was 8.0% at 0-5cm from the colony front edge, 6.2% at 10-15cm and 6.5-7.5% at 20-40cm. And the content was 12.1% at 80cm distance from the colony edge, which is similar to that at the non-colony. In contrast, ergosterol content which is proportional to the live hyphal biomass was only 0.4μg/g fresh soil at the uncolonized soil, while 4.9 μg/g fresh soil at the front edge where the hyphae actively grow, and 3.8 μg/g fresh soil at the fruiting position, 1.1μg/g at 20cm distance and 0.4μg/g in the 40cm rear area. Generally, in the Tm fungal colony the water content changes were reversed to the ergosterol content changes. While the site was watered during August to October, the soil water contents were 13.5 ~23.0% within the fungal colony, whereas it was 14.5~26.0% at the non-colony. That is, soil water content in the colony was lower by 1.0~3.0% than that in the non-colonized soil.

Our results show that Tm colony consumes more soil water than other parts. Especially the front 30cm within the hyphal colony parts is more critical for soil water absorption.

Keywords : Soil moisture change, Tricholoma matsutake fungal colony, Water absorption, Below-ground colony, Ectomycorrhizas, Ergosterol.

Introduction

Tricholoma matsutake (TM, Pine mushroom) is economically and ecologically significant because it is the most popular edible mushroom in Asian markets and it forms ecto-mycorrhizas with Pinus densifloraroots and it requires site specific niche (Yamada et al, 1999).

Water is critically important for pine mushroom growth because it is the major component of the mushroom by about 90%. Water is absorbed thru below ground hyphae (Kim et al, 1999). However, relationships between soil water and fruit body growth, the amount of water required for the growth, the optimal soil water content for the mushroom, etc have not been investigated yet. TM is one of the most valuable non-timber forest products in Korea with worth over 30 million US$ per year(Koo et al., 2001).

The Objective of this study is to understand water dynamics in below ground fungal colony, critically important zone for absorbing water within the colony, relationships between soil water status and hyphal vigor.

Materials and Methods

1. Experimental plot

Fungal Colony

Below-ground TM colonies were identified in Sogni Mt National Park in South Korea (Figure 1). Within the colonies actively growing zone, fruit body forming zone and mycelium degrading one were gradual.

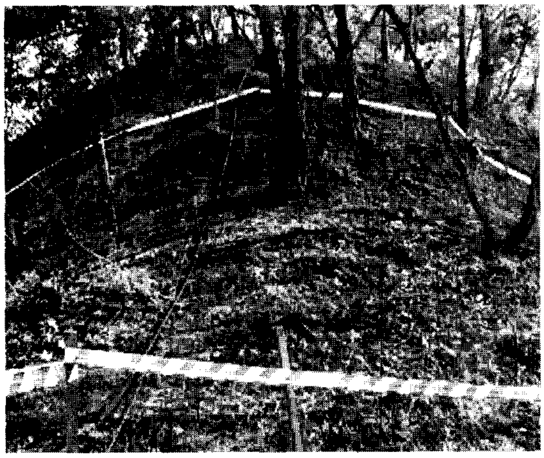

Fig. 1. Expermental plot for investigating the soil water change in Tricholoma matysutake production forest at Ssanggok valley in Songni Mt National Park. Irrigation system was established.

Measurement of soil moisture dynamics

Two sensors of Time Domain Reflectometry were established within a colony: at 15cm from the colony edge and non-colonized front (Figure 2). This set was replicated at three colonies. Soil water data were recorded every hour with CR10X data logger from August 15 to October 30, 2001. This area was irrigated every other or third day for the mushroom fruiting during the measurement, because the soil water was less than 10%, which is not enough to fruit. Soil water content within the fungal colony was measured every 5cm from the colony front edge with HydroSenseTM in June 2002 (Table 1).

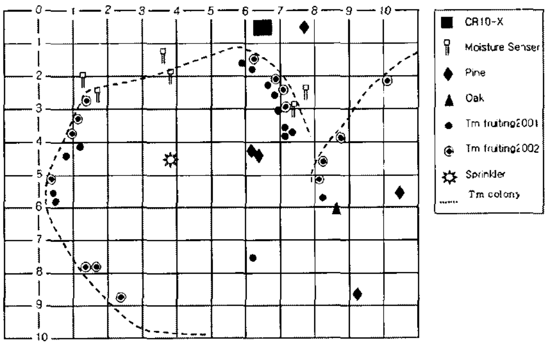

Fig. 2. Tricholoma matsutake(Tm) colony TDR sensor map at the experimental site in Ssanggok valley, Sogni National Park. Positions of TDR(Time Domain Reflectometry) moisture sensors were in outer(-10 to -5cm) from and inside(5 to 10cm) from the colony front edge. The sensors are connected to the CR10X data logger that records soil moisture data during the experimental period. And a temperature sensor was located close to the moisture sensor.

Measurements of hyphal vigor: ergosterol content

To identify the critically important zone the colony front edge line was marked. Soil colony samples

Table 1. Characteristics of Tricholoma matsutake (Tm) soil colony

Fungal colony		Characteristics of Tm soil colony, mycorrhizas and soils
Division	Position(cm)	
Outer	-5~0	Outside of Tm colony front that Tm hyphae grow into later; water content is higher and root density is lower in this non-colony than Tm colony.
Front edge	0~5	White fungal colony mass with actively growing hyphae, feeder roots and soil; water content is less than in the outer.
Tm fruiting position	10~15	White and firm fungal colony mass of hypahe, shrunk brown black feeder roots and soils; water content is less than in front edge; current year mushroom fruiting position.
Rear	20~25	White powdery colony; shrunk black feeder roots peeled to show light brown surface: previous year mushroom fruiting position.
	40~45	Gray powdery colony; root density is lower than the previous colonies; tips are very weak.
	80~85	Gray powdery colony with lower root density; other types of ectomycorrhizas develops.

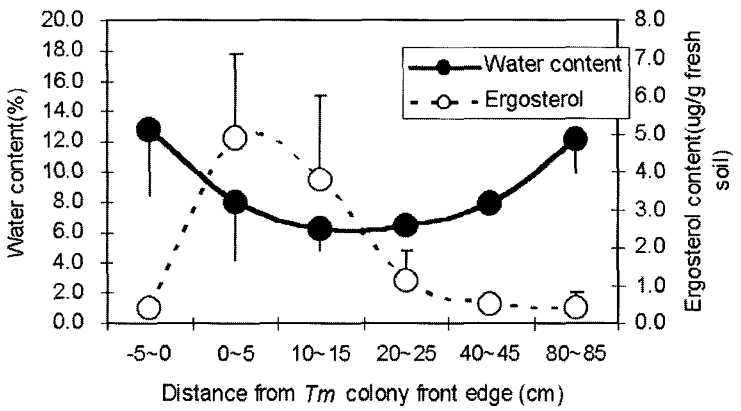

Fig. 3. Water and ergosterol contents of Tricholoma matsutake(Tm) soil colony

were collected at non-colonized, colony edge, 10cm, 20cm, 40cm, and 80cm positions from the edge. Ergosterol content of the soil sample were analyzed according to (Nylund and Wallander (1992) and relative soil water content of the soil was measured with HydroSense.

Results and Discussion

1. Relationships between soil water and ergosterol content

Soil water content variations within the colony were compared with ergosterol content variations by the positions in the colony(Figure 3). Before irrigating the site soil water contents were 12.8% at the fungus uncolonized front, 8.0% at the active hyphal colony edge, 6.2% at the mushroom fruiting position and 12.1% at the hyphae decaying rear region. In contrast, ergosterol content which is proportional to the live hyphal biomass was only 0.4μg/g fresh soil at the uncolonized soil, while 4.9μg/g fresh soil at the front edge where the hyphae actively grow, and 3.8 μg/g fresh soil at the fruiting position, 1.1μg/g at 20cm distance and 0.4μg/g in the 40cm rear area.

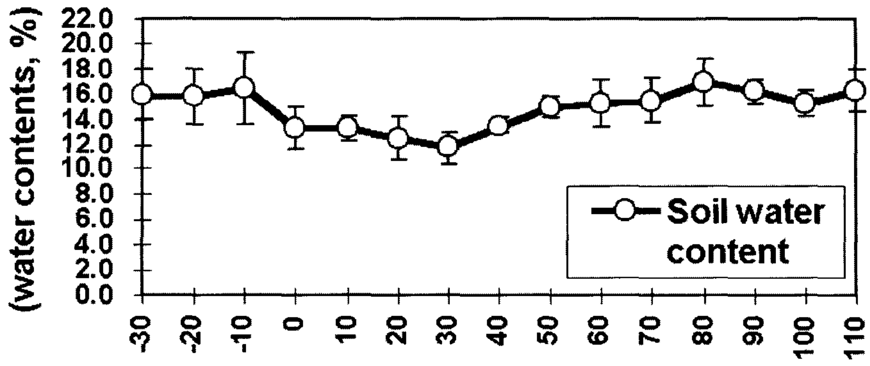

Fig. 4. Soil moisture changes within Tricholoma matsutake soil coloies by distance from the colony front edge. The values are the mean of three replications and standard deviation.

Generally, in the Tm fungal colony the water content changes were reversed to the ergosterol content changes.

Soil water content within Tricholoma matsutake soil colony in June, before monsoon started, was 12% in non-colonized soils (-20～0cm) while it was less than 10% in the colonized soils (0～100cm). The value in the colony was consistently low. One of the possible reasons for this low water is that profuse and dense hyphae and ectomycorrhizal roots consume the soil water during repiration and transpiration. Under this low water levels the hyphae does not seem to grow well.

The soil water content was lower in colonies than in non-colonies by about 1.3%. Because of severe drought in 2001, when this area was watered every third day during August to October, the differences decreased but soon increased as soil dried. These dynamic soil water changes mean that T, matsutake colony soils gets water stress more rapidly than the non-coloy. However, it does not explain that the hyphae are hydrophobic.

Without irrigation in 2001 in that area no mushroom fruited. Thus, monitoring the water content in the actual fungal colonies are critical for the fruiting. We suggest soil water level should be at least 15% for fruiting.

2. Spatial soil water change in Tricholoma matsutake colony

Before irrigation, whereas it was 12.8% at non-colony, the soil water content within Tm colony was 8.0% at 0-5cm from the colony front edge, 6.2% at 10-15cm and 6.5-7.5% at 20-40cm. And the content was 12.1% at 80cm distance from the colony edge, which is similar to that at the non-colony (Figure 4).

3. Temporal soil water change in Tricholoma matsutake colony

While the site was watered during August to October, the soil water contents were 13.5～23.0% within the fungal colony, whereas it was 14.5～26.0% at the non-colony. That is, soil water content in the colony was lower by 1.0～3.0% than that in the non-colonized soil (Figure 5).

Conclusion

Soil water contentwas lower by 2～6% in below-ground TM colonies than in the non-colony. Colony front edge and fruiting zones are the most water

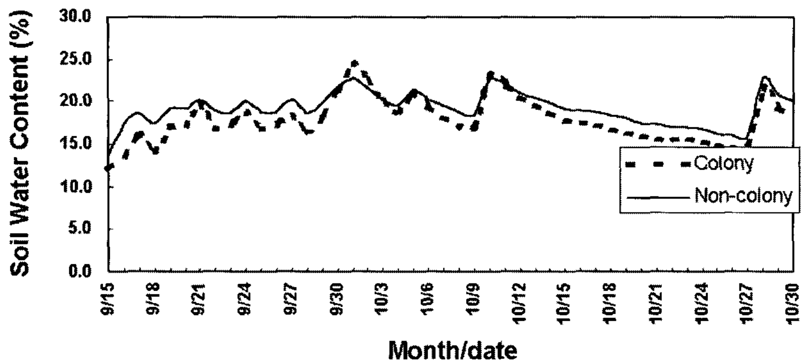

Fig. 5. Soil moisture change in Tricholoma matsutake colony during late August to mid October in 2002

demanding active hyphal zone.

Water monitoring in the fruiting zone is critically important for the fruiting management.

References

Beyer, D.M., K.M. Lomax, R.B. Beelman. 2000. The use of time domain reflectometry to monitor water relations in mushroom substrate and casing. 15th Science and Cultivation of Edible Fungi. pp. 341-348.

Duncan, S. 2000. Symbiosis and synergy: Can mushrooms and timberbe managed together? Science Findings. Pacific Northwest Research Station. issue 28/ October 2000. 5p.

Kalberer, P.P. 1991. Water relations of the mushroom culture(Agaricus bisporus): Influence on the crop yiels and on dry matter content of the fruit bodies. Science and Cultivation of Edible Fungi 1:269-274.

Koo, C.-D. and E.M. Bilek. 1998. Financial analysis of vegetation control for sustainable production of Songyi (Tricholoma matsutake) in Korea. Jour. Korean For. Soci. 87:519-527.

Noble, R., T. Rama, A. Dobrovin-Pennington. 2000. Continuous measurement of casing soil and compost water availability in relation to mushroom yield and quality. 15th Science and Cultivation of Edible Fungi. pp. 433-440.

Nylund, J.-E. and H. Wallander. 1992. Ergosterol analysis as a means of quantifying mycorrhizal biomass. In Methods in Microbioloy. Vol. 24, Techniques for the Study of Mycorrhiza. Edited by J.R. Norris, D.J. Read, and A.K. Varma. Academic Press. London. pp. 77-88.

Yamada, A., S. Kanekawa and M. Ohmasa. 1999. Ectomycorrhiza formation of Tricholoma matsutake on Pinus densiflora. Mycoscience 40:193-198.