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Biology of *Tricholoma matsutake* found at *Pinus densiflora* communities in the areas of Kyoung Sang Do.

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경상도지역의 소나무 (赤松) 군락에서 발견된 송이의 생물학

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ABSTRACT: From 1986 to 1990, the fifty-three sites (shiros) of the five places known as an areas of the pine-mushroom production in Kyoung Sang Do were visited, investigating the biology or ecology of pine-mushrooms. Physical or ecological characteristics of the areas producing pine-mushrooms was similar to those reported in Japan, but not similar to in this regardings; The ages of pine trees, the understory plant flora of the places producing the pine-mushrooms and the soil types. The areas of pine-mushroom productions are divided to two typical areas, the inland and coastal areas. Ecological differences between two areas were found, The understory plant flora and different soil types. Three kinds of soil were, by the naked eyes, were found from our observations of Kyoung Sang Do, but not based on soil analysis. The pine-mushrooms observed in Kyoung Sang Do were related to the root of the pine trees, but not confirmed to be ectomycorrhizally related to the pine trees. The mycelia isolated form the different places were compared with the degradation of phenolic compounds and culture methods, but were not clearly distinguished. The productions of pine-mushroom and several methods for the pine mushroom were suggested under four years' observations.

KEYWORDS: ***Tricholoma matsutake,*** **Biology, Ecology,** ***Pinus densiflora,*** **Korea.**

Tricholoma matsutake Singer is a traditional foodstuff, known as a king of mushrooms in Eastern Asia. The pine-mushroom (called "matsutake" in Japan) is normally collected in the early fall at the communities of *Pinus densiflora* and smells of the strong odor of pine trees. Recently, its great demands by Japenese and Korean people have increased and contributed to the local economy of the Eastern Coast areas in Korea (Office of Forestry, 1981a: 1984). Therefore, little has been known about the pine-mushroom in Korea, as compared with the great demands.

Mycelia of pine-mushrooms were reported to be closely associated with the roots of *P. densiflora* as termed "ectomycorrhizae" (Ogawa and Ohara, 1978; Ogawa, *et al.*, 1980). It is considered to directly infect the fine feeder roots and to colonize on the cortical or epidermal cells at the roots in *P. densiflora* (Ogawa, 1976; 1978). Thus, the mycelia of *T. matsutake* are considered to stimulate the growth of *P. densiflora* (Ogawa, 1977d), although a detailed physiological relationship between them is not clear. The mycelia of *T. matsutake* are reported to colonize around the fine roots (causing witch blooming at the roots) and considered to receive the nutrients from the fine roots of *P. densiflora* (because all fungi are heterotrophic). However, it was not understood what benefit the mycelia give to the pine trees. The question "What kind of nutrient does *T. matsutake* mycelia provide to pine trees ?" or "How does *T. matsutake* mycelia help the pine trees?" remains.

Generally speaking, the pine-mushroom has been collected under communities of pine trees, which grow in poor-soils (for example, ridge or steep areas in the mountains: Ogawa, 1977a: 1977 b: 1977c). Also, poorly growing pine trees have been cited to be related to pine-mushroom production by the local collectors. The local or smaller places producing the pine-mushrooms are referred to as the "shiro" first defined by Japanese scientists (Ogawa, 1981: Ogawa and Ohara, 1978: Ogawa *et al.*, 1980). Shiro is a small local site producing matstake mushrooms under the soil around pine trees with both the mycelia of *T. matsutake* and the roots of *P. densiflora* (Ogawa, 1981). In the detailed observations of shiro, numerous fine roots (less than 1 mm dia.) of pine trees are formed that "witch bloom" at the base of a basidiocarp stipe of *T. matsutake* (Ogawa, 1976; 1981). The countless fine roots are partially associated with the white mycelia of *T. matsutake* and turn to the dark or brown color (Office of Forestry, 1981). Shiro is understood to be a matrix of the special soil (slits or fine sands) consisting of the fine roots of *P. densiflora* and the white myceila of *T. matsutake* under/around the pine tree (Office of Forestry, 1981b; 1984; 1986). The sands or slits of shiro are reported to be naturally made in special environments (less than 22-28% of moisture, slightly acidic soils indicating pH 4.7-5.9: Ogawa, 1977d).

The life cycle of the *T. matsutake* has not been clearly undrestood, but predictable, in spite of the numerable studies conducted in Japan for at least a hundred years (Ogawa, 1977d; 1981). *T. matsutake* have been reported to be naturally harvested from the commumities of several species of *Pinus, Tsuga, Picea* and *Abies* (Ogawa, 1977d; 1979; 1985; 1979: Ogawa and Ohara, 1978). In most cases, ectomycorrhizal associates with *T. matsutake* with the above mentioned plants were reported to occur in the poor soils, indicating that poor growing soils are less-humic soils (Ogawa, 1977d; Office of Forestry, 1984).

These experiments were the first studies of basic information between the fungus, *T. matsutake,* and the plant, *P. densiflora,* in southern-eastern Korea. Also, I tried to study the ecology of pine-mushrooms in the Korean Mountains and to understand the ectomycorrhizal relationships between pine-mushroom fungi and pine roots.

Materials and Methods

Collection areas: The five collecting areas were A and B (the back mountain of Pal Gong near Pu In Sa in Taegu), C area (the front mountains of So Jeong Ri, Puk San Myun, Geo Chang Kun, Kyoung Nam), D area (the side mountain of Bo Kyoung Sa, Song Ra Myun, Young il Kun, Kyoung Puk), and E area (the back mountains of Seok Ryu Cave, Ul Jin Kun, Kyoung Puk). The five areas were visited during the periods of the pine-mushroom production, the third or fourth week of September, the year of 1986 to 1990. The area of So Jeong Ri (C) was visited on the same period of 1987 and the pine-mushrooms were collected near the small communities of *P. densiflora.* The individual places producing pine-mushrooms in the above areas (except for C area) were guided by the local collectors of pine-mushrooms. During the time that local collectors guided, the crude information for special areas producing pine-mushrooms were described in Table I.

Observations of pine-mushrooms and plants: The basidiocarps of *T. matsutake* were collected or stored in the 5% formalin solution and the spore print of them was directly obtained on black paper for the color of white spores. The observation of the basidiocarps or the basidia of *T. matsutake* was done on the light microscope and on a Scanning Electron Microscope provided by the Institute of Agricultural Science, R.D.A. (Suweon 440-707, Korea).

Isolations of Mycelia: The pieces of the sterile basidiocarps were placed on the GS agar defined as a selective agar for basidiomycetes (Ginterova and Janotkova, 1975). The mycelia obtained from several transfers were stored on the complete media (Raper and Raper, 1972) and compared with the other isolates of *T. matsutake* provided by Ogawa (the stock mycelia directly isolated from the field studies). The oxidations or hydrolysis of six different phenolic compounds were mentioned by Kirk and Kelman (1964) and were employed for distinguishing the mycelial isolates. The soil profile of the promordia, *T. matsutake,* was also observed as Ogawa's experiments (Ogawa *et. al.,* 1978; 1980: Ogawa and Yambe, 1980: Ohara and Ogawa, 1982). The roots of *P. densiflora* connected with the mycelia of *T. matsutake* were confirmed and the plant odor was compared with those not connected with mycelia of *T. matsutake.*

Ecological observations: The age of *P. densiflora* was measured with a cork borer for plants older than 20 years or with counting the nodes on the young plants. The slope of the sites producing pine-mushrooms was also measured with the compas. The different soil types of the sites producing pine-mushrooms were distinguished by the naked eye, or by a standard soil analysis, done by Laboratory of Soil Science, the Institute of Agricultural Science, R. D. A.

Results

Identifications: The mushrooms collected from the different places (see Table I) were identified as a basidiocarp of *T. matsutake.* The color variations on pileus of *T. matsutake* were shown among the different collecting places, but was not specified in these experiments. A detailed description of collected mushrooms follows;

"The mushrooms tricholomoid are growing up in the soils or humus mixed soils. Basidiocarps, sized with 10 to 25 cm height of stipe x 8 to 15 cm diameter of pileus, and brown to dark brown on the upper cap. The basidiocarp hemiangiocarpically developed (Fig. 4). The stipe is white up to brown, and centric (1.5 to 3 cm diameter). The veil on the stipe is present when the fresh but disappeared soon (Fig. 1). Gills laminated with thin acute edges are not thick nor waxy decurrent with the parallel trama (Fig. 2b). Typical four spored basidia (Fig. 2b and c), The spores ellipsoid, white, and nonamyloid in the Melzer's reaction. Odor of basidiocarps smelled of the odor of pine trees.

Sites of pushroom productions: The crude information on the places producing mushrooms were shown in Table I. The productivity of mushrooms

Table I. The crude informations of *Tricholoma matsutake* collecting places and sites.

Places marked[a]	The numbers of sites observed	Ages of *P. densiflora*[b] communities(Years)	Productivities[c] Productivities[c]
A	11	9-18	100
B	12	20-70	500
C	12	18-80	–
D	8	50-100	5,000
E	10	40-80	1,000

[a] The locations of *T. matsutake* collecting sites: A and B=The back mountain of Bu In Sa in Pal Gong San, Taegu, C=The front mountain of So Jeong Ri, Puk San Myun, Geo Chang Kun, Koung Nam, D =The side mountain of Bo Kyoung Sa, Young Il Kun Kyoung Puk, and E=The back mountain of Seong Ryu cave, Ul Jin Kun, Kyoung Puk.

[b] The ages of youngest and oldest pine trees at *T. matsutake* collecting sites

[c] The contract money (x 10,000 Won/Year) of Rights for the collection of *T. matsutake.* The productivity of *T. matsutakes* in the place C not estimated because of the public mountains.

was estimated as the Annual Rights for collections of the pine-mushrooms. The areas or places around Pal Gong San, (A, B), Po Kyoung Sa (D), and Ul Jin (E) were all private mountains and well protected by the local collectors for pine-mushrooom productions. The area C of Geo Chang was the only public mountain and the pine-mushrooms collected by local amateur collectors. The areas, D and E, were known as the famous places for producing pine-mushrooms in and on the mountains near the Eastern Coast. Also, they (D and E areas) were competely different from others (A, B, and C areas) in several ecological features; slope of Mountain, flora of plants, and soil types, as based on the observations of 53 sites among five different areas and communications with the local collectors of pine-mushrooms. The sites producing pine-mushrooms should not be a common site, but should be a special site, so called "shiro"; The areas located between both sides 10-20 m from the ridge, and deep slope of the areas (18.0-35.0% by the water content) with the poorly growing pine tree communities (shown pale green as compared with the dark green in the pine tree communities not producing pine-mushrooms). The young trees were comparatively observed as the

Fig. 1. Basidiocarps of *Tricholoma matsutake* collected.

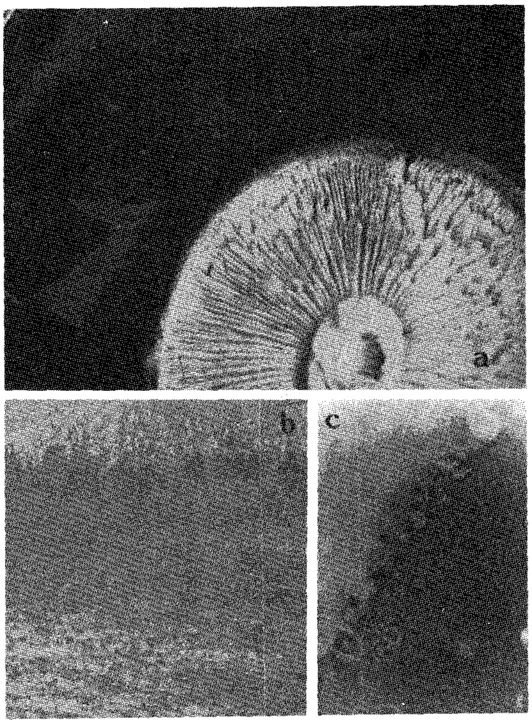

Fig. 2. Morphology of *T. matsutake* basidiocarps; a) Gill shape, the red arrow indicated the white spore print under the naked eyes, b) basidium and parallel type in gill trama, 8×40, and c) basidium and four basidiospores, 8×80.

trees producing pine-mushrooms at the areas A and B in Pal Gong San. The growing states of pine trees were all poor as compared with those at another areas in the same mountains (the foot of mountains). The ages of pine trees in D and E areas were high as compared with those in the other areas. Many rocks were distributed in the D and E areas (Table I). The small communities of pine trees (composing of less than ten pine trees in the area C were often distributed throughout the mountains by a long disance (at least 100 m) and were mixed with the communties of oak trees. *Rhododendrom schilippenbachii, Quecus dintata, Rh. mucronulatum, Fraxinus rhynchophylla,* and *Lespedeza bicola* were occasionally found in the shiro as the understory plants (Table-II). These species of grass family were found in the shiro of the area D and E, but not identified in this experiment. The two species of *Rhododendron* were frequently found in the inland areas A, B, and C. Several herbaceous plants (belong to to family of grass) were found in the areas of D and E but not identified here. However, the findings of understory plants described in Table II were not consistent with the other sites of the pine-mushroom producing areas.

Shiro and soils: The local sites called "shiro" were 53 sites shown in Table I. The distance between the sites producing pine-mushrooms and standings of pine trees was estimated, but not related to pine-mushroom production. Three figures of Fig. 6 indicated the different soil types; The clay (CL), the silt (M), and the soil mixed with the fallen pine leaves (FPL) were recognized by the naked eyes in this expemiment but not done with the standard soil analysis. The communications with the local collectors had two different opinions: The inland collectors (A, B or C areas) mentioned M and FPL type soils as a shiro, but the coast collectors of D or E areas CL type soil as the shiro. The M type soil was found in the areas of A, B, and C, but not in the areas D and E. The M type soil was different from the soil of surrounding areas of the shiro at the color and the sand size of the soil by the naked eyes. Particularly, M type soil found in the area C was completely different from the surrounding soil at the color of soil, and the CL and M types recognized in this experiments were analyzed in Table III, determining to both a sand loam. The oganic contents of the soil were removed, when collected,

Table II. The plant flora of the *T. matsutake collecting* sites[a].

Scientific names	Korean names	Areas of *T. matsutake*[b] Collecting sites
Rhododendron schilippenbachii Max.	연달비 (진달래과)	A (2), B (2)
Quercus dentata Tunb.	참나무 (참나무과)	A (2)
Rh. mucronulatum Turcz	진달래 (진달래과)	A (5), C (3)
Fraxinus rhynchophylla Hance	물푸레나무 (물푸레나무과)	A (1), C (2)
Lespedeza bicola Turcz	싸리나무 (콩과)	A (1)

[a] The trees found in *T. matsutake* collecting places A, B, C, and only herbaceous plants observed in the places of D and E.
[b] The numbers of sites indicated the numbers of *T. matsutake* sites found.

in the CL type-soils. The analysis of them (M or CL type of soils) did not give any difference except for the composition of soils. However, the observation for the soil types (M, CL, and FPL types) done in this experiments and by the naked eyes was more accurate than the analysis of soil. The FPL type soil was a mixed sand with the fallen pine leaves at the approximate rate of 1 : 3, and easily recognized with other two types of soils, M (more sand) and CL (more clay).

Mycelia with pine roots: The mycelia at the base of basidiocarps of *T. matsutake* were always associated with the fine feeder roots of *P. densiflora* (see Fig. 6 CL). The basidiocarps related to the pine roots were shown in Fig. 6a and the detail roots with white mycelia were also shown in Fig. 5b. The pine roots shown in Fig. 5b were observed by the 25 x dissection microscope. The white mass of the mycelia was fatteningly distributed around the base of *T. matsutake* basidiocarps and in the soil mixed with the fine roots of *P. densiflora.* Fig. 5 was a picture of *T. matsutake* basidiocarp washing by the water and indicated the relation of *T. matsutake* basidiocarp with the fine roots of *P. densiflora.* The detail observation of the roots was that the fine roots associated with mycelia presented appeared dark but those not associated with mycelia pale brown (See Fig. 5 b). The results of Fig. 5 indicated the relationship of *T. matsutake* basidioarps with the *P. densiflora* roots.

Isolates of pine-mushroom mycelia: The mycelia were directly isolated from the sterile tissues of basidiocarps with alcohol flame thoughout dissections. More than twenty mycelia marked "TM series" were evenly isolated from the five different areas shown in Table I. The mycelia isolated by GS agar and grown on CM agar were observed and examinated through the microscope. The myceila of each isolates did not shown any clamp connections nor any special features of basidiomycetidae. Four different types of mycelia were recognized by naked eyes in Fig. 7; 1) White mycelium covered in agar, 2) Mycelial mats covered in agar and leathery form appeared, 3) Mycelium growth like 2, but the leathery form covered a pale pink color, and 4) Mycelium growth like 2 but the mycelium matrix showed the brown color.

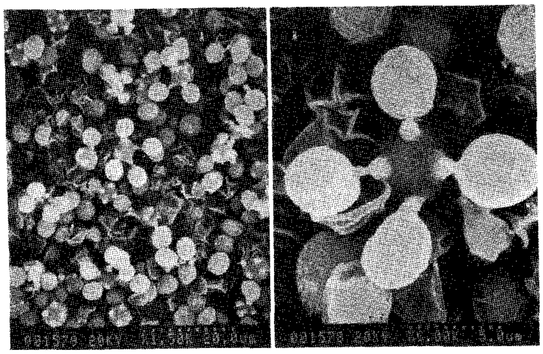

Fig. 3. Scanning electron microscope of *T. matsutake;* a) basidia with the sterile basidia, x1,500, bertile basidium with four basidiospores, x6,000.

Biochemical reactions of mycelia isolated with the response for the phenolic compounds were shown in Table V and done for physiological difference of twenty isolate types of *T. matsutake*

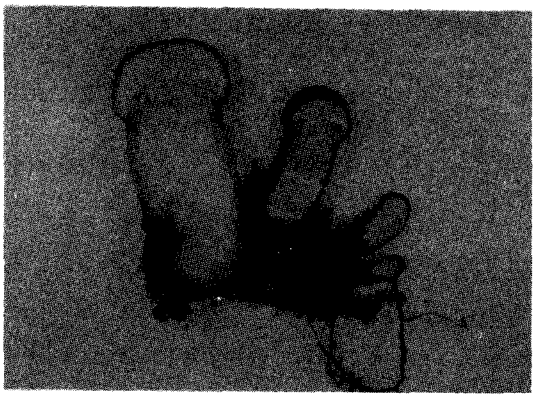

Fig. 4. Hemiangiocarpous development of *T. matsutake* basidiocarps.

Table III. The soils of *T. matsutake* collecting sites[a]

Places	The soils of *T. matsutake* collecting[b] sites (The numbers of sites found)
A	M (5), CL (1), EPL (5)
B	M (7), FPL (5)
C	M (12)
D	CL (8)
E	CL (10)

[a] The soils of the *T. matsutake* collecting sites observed

[b] M indicated the white gray soils CL the brown or red soils, and FPL a mixture of the fine sand with fallen pine leaves. The soil analysis of M on the place of C was (Sand: Silt: Clay=69.9 : 26.5 : 3.6) and CL (59.5 : 25.1 : 15.4), and both indicated a sand loam.

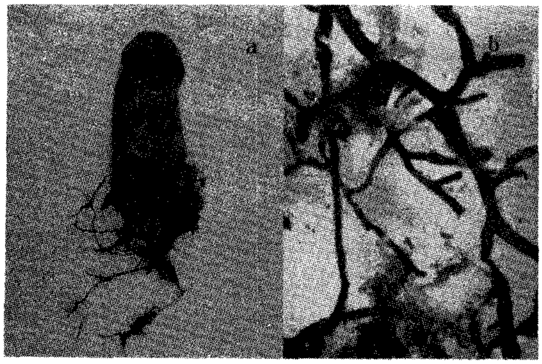

Fig. 5. Ectomycorrhizal relationships of *T. matsutake* mycelia mixed with the roots of *Pinus densiflora* at the base of a basidiocarp; a) observed under the naked eyes, and b) dark roots interwoven with mycelia, x 40.

Fig. 6. The soil types of sites or shiro producing *T. matsutake;* A) CL type brown and red soils, B) FPL a mixture of the fine sand with the fallen pine leaves, and C) M the white grey soils.

mycelia. The mycelia of JT series obtained and identified by Dr. Ogawa were employed as the stanard mycelia and compared with the Korean mycelia directly isolated. The species of JT series were not decribed here because the taxonomy of *T. matsutake* was not clear by Singer (1986) until now. The responses of the isolates with phenolic compounds appeared different. TM-1, TM-7, and TM-8 mycelia showed the same responses as compared with the others. Two responses (+, −) of each isolate on phenolic compounds shown in Table V were replaced with the values (1, 0) for the cluster analysis, respectively. The calculations of dissimilarities of two pairs of isolates were based on the ecological analysis (Ludwig and Renold, 1988). The analytic data not shown here indicated that TM-1 was closely related to TM-7 or to TM-8, and that TM-2 to TM-3 or TM-4. However, TM-9 was calculated to be not related to any TM-series, namely the isolate of TM-1 or TM-2. These results were not consistent with those observed in Table IV and Fig. 7.

Discussions

Identifications: Singer (1986) divided the genus *Tricholoma* into several groups (subgenus or sec-

Table IV. The mycelia isolated directly from the tissues of *T. matsutake* basidiocarps collected in the fields.

Types[a]	Descriptions of Mycelia[b]	Isolates
TM-1	White mycelia covered	TM-1, TM-4
TM-2	Leathery mycelia covered on agars	TM-2, TM-10 TM-11
TM-3	Leathery mycelia showed pale pink	TM-3, TM-5 TM-6
TM-7	Leatery mycelia showed the brown color.	TM-7, TM-8 TM-9

[a] The typical mycelia isolated from the tissues of *T. matsutake* basidiocarps collected at the mountains and obtained by the surface sterilization.

[b] The mycelia grown on Complete medium, and sometimes, grown on Malt agar for more than twenty days' incubation at the room temperature.

tion) and uncertainly described sect. eight genuina (Fr.) Sacc. as a group of *T. matsutake*. Also, the special mushrooms are mentioned to be associated with the conifers (Singer, 1986). Imazeki and Hongo (1984) mentioned the strong odor of pine and the size of pileus for identification of *T. matsutake*. Our identification of this mushroom was based on Smith's description at the level of genus (1974) and based on Imazeki and Hongo's (1984) descrip-

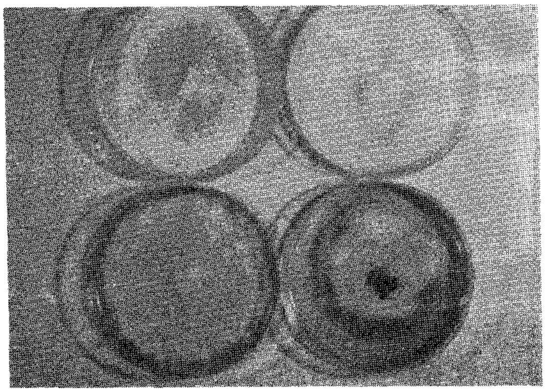

Fig. 7. Four different culture types of *T. matsutake* mycelia directly isolated from the tissues of basidiocarps and artificially grown at the Complete Medium.

tion at the level of species. The mushrooms collected in this experiment were consistent with the description of the genus *Tricholoma* and have the affinity with Imazeki and Hongo's (1984) description of *T. matsutake*. The color variations of pileus was found in this experiment, but was not important because of the local variations.

Hundreds of mycelia were believed to be isolated from the natural *T. matsutake* but nobody identified them as a mycelium of *T. matsutake* because the process of mycleia to basidiocarps in *T. matsutake* was not suceessful in the world. Japanese Forest Research Institute have hundreds

Table V. Biochemical responses of phenolic compounds for the isolates of *T. matsutake*.

isolates[a]	Catechol[b]	α-naphtol	Syrinaldehyde	Tannic acid	Vanillin
JT-4	−	−	−	+	−
JT-5	−	+	++	−	+
TM-1[c]	+	++	+	+	−
TM-2	−	−	+	+	−
TM-3	−	−	+	+	+
TM-4	+	−	+	+	+
TM-7	+++	+++	+	+	+
MT-8	+	+	+	+	−
TM-9	++	++	−	−	−

[a] The isolates of JT series obtained from Dr. Ogawa, M. and known as mycelia of *Tricholoma* species. The isolates of TM series directly isolated from the basidiocarps of *T. matsutake* in Korea

[b] The phenolic compounds (1 mM) and tannic acid (0.5 %) added to 2 % malt agar described by Kirk, were employed here.

[c] Groupings as based on the cluster analysis: (TM-1, TM-7 or TM-8), (TM-2, TM-3, or TM-4), and (TM-9).

of *T. matsutake* mycelia including the mycelia of different species of *Tricholoma* (Ogawa, 1976: 1977 abcd: 1979ab: 1981). Biochemical responses of the mycelia isolated by Ogawa and me were represented in Table V. Observation of TM-isolates by naked eyes was not consistent with biochemical responses shown in Table V. The cultural characterestics of *T. matsutake* mycelia showed four different types described in the results and in Fig. 7. The two kinds of culture characteristics of *T. matsutake* mycelia (TM-2 and 3 Types in the results) were agreed to *T. matsutake* researches of FRI (personal communications), but not to those of RAI (personal communications) in the fast growth. However, all mycelia mentioned in Table IV were originated from the tissues of *T. matsutake* basidiocarps. Biochemical responses of *T. matsutake* mycelia were conducted with twenty differnt carbohydrate by Ogawa and Ohara (1978), but did not give any distinct difference between (among) the different mycelia. Oxidation or hydrolysis of phenolic compounds by *T. matsutake* mycelia was considered to give the difference among the different mycelia and some genetic variations of the mycelia isolated. The conclusive results were not conducted from Fig. 7 and Table IV because the small amounts of data. The further works for these would be needed for the confirmation and genetic variations of *T. matsutake* mycelia.

The areas producing pine-mushrooms: Forest Research Institute (FRI, 1981a) mentioned that the areas producing *T. matsutake* were geographically described as the special areas of *P. densiflora* communities located at both sides of the ridge of mountain hill and composed of humic poor and mineral soils with the steep slope. These observations for the areas producing *T. matsutake* were consistent with our observations found in the five different places. Biological relationships of the understory plants for *T. matsutake* productions were conducted for the indication for *T. matsutake* productions, but only relationship of understory plants was not found with the areas producing pine-mushrooms. The observation of *P. densiflora* in the area A was considered to be releted to the results of the succession of plant commuinities because of the mountain fire reported by the local collectors and observations of the dark trunk of big *P. densiflora*. The understory plants were considered to grow with young pine trees after the fire. Japanese scientists' observations for those were also not consistent with our obsertions except for the species of *Rhododendron* genus (Ogawa, 1976). However, our observations for understory plants were similar to those done by FRI workers at several species of understory plants. It was conclusive that the physical relationships mentioned in the above should be better indicators than the biological relationships of understory plants for *T. matsutake* productions.

In Japan, *T. matsutake* mycelia colonizes the roots of *P. densiflora* with the ages under 20 year old plants, and the maximization of production of *T. matsutake* was under the trees of *P. densiflora* aged around 20 to 40 years old (Ogawa, 1976). These results done by Japanese Scientists were consistent with those conducted in the inland places of A, B, and C. The productions of pine-mushroom were evenly distributed at the communities of *P. densiflora* with ages of 10 to 100 years old in Korea. The Eastern Coast places, D and E, were known to the best areas of *T. matsutake* productions, because the ages of *P. densiflora* were considerably high as compared with those in Japan (see Table I of Ogawa, 1976). The principal component and the cluster analysis were conducted with the biological charateristics (Table I) and the soil types (Table III), although the data shown in two Tables I, II were not sufficient (Ludwig and Reynold, 1988). The results were not shown here, but indicated that the places geographically have similarities each other. The place of A or B was considered to be similar to that of C, but to be not to that of D or E on basis of the cluster analysis. This difference between the areas of the East Coast (D, E) and inland (A, B, and C) was considered to be due to the different locations, environmental factors (Rain fall), and unidentified factors, which were not measured under this circumstances.

Shiro (송이울): The shiro was a Japanese term related to the soil producing the basidiocarps of *T. matsutake*, but also a term to define the special type of soils. The shiro was not geologically defined but biologically defined. It was defined as a soil mixed with the mass of *P. densiflora* root and *T. matsutake* mycelia, and also as the site producing the basidiocarp of *T. matsutake* every year. The shiro was not a fixed nor unchangeable site at the special sites of *P. densiflora* communities and moved to the big circular type around the *P. densiflora* root soil with a 10 to 15 cm / year increase (Ogawa, 1978; 1979). Here, shiro should be very important in the productions of pine-mushrooms, but not described well in the previous studies. So, the different type soils mentioned in Fig. 6 were considered to be very important in the relationships between the pine trees and pine-mushrooms and also referred to the soil of the shiro mixed with plant roots and mycelia.

The first described in the sands in the two types of shiro (CL and M) showed a little difference from each other, but their soils were determined to "silt loam soil". Particularly, the soils producing *T. matsutake* (FPL and M) were found in the inland areas (A, B, and C) but not in the coast areas (D and E). The soil type producing *T. matsutake* which the inland collectors mentioned were completely different from those which the coast collectors mentioned. The type soils (CL) in Fig. 5 found in the coast areas (D and E areas) were rarely found in the inland areas (Pal Gong San and Deok U San). Also, the CL type soil was consistent with Ogawa's description for the soil profile of *T. matsutake* production areas although he did not mentioned CL type soil. Both CL types mentioned at the D and E areas in Korea and special areas in Japan have the similarity of locations near the East coast. The M type soil found in Fig. 6 was called "Masato (translated to "Slit soil") by local collectors in *P. densiflora* communities. The M soil, as high values of sands in soil compositions, was considered to be originated from the environmental soil but from the wind blowing sands in Spring. The different soil types producing *T. matsutake* (FPL and M types) were newly described in this experiment, although any difference between them was not found in the soil analysis.

Ectomycorrhizal relationships: Ectomycorrhizal relationships of the roots of *P. densiflora* with *T. matsutake* mycelia were reported in several articles (Dr. Ogawa in the reference), but the symbiotic relationships of them were not determined like the relationship between the legume plants and *Rhizobium*. The pine trees must grow poorly at the ridges of mountains and also must be observed to be related to the mycelia of pine-mushrooms at the fine feeder roots. However, a clear evidence for ectomycorrhizal relationships between them was not found throughout my observations, although they were defined as a symbiosis. The parasitic relationships of *T. matsutake* to the root of *P. densiflora* were represented in Fig. 5a and b. The white mycelia of *T. matsutake* surrounded around the root of *P. densiflora* and turn the color of the root to the dark brown. This results were consistent with Ogawa's observations. Therefore, the role of *T. matsutake* mycelia was not found in Fig. 5 and not speculated to help the growth of *P. densiflora*. The results from Fig. 5 indicated that the mycelia of pine-mushrooms substract the nutrients from the roots of *P. densiflora* because the hundred of root surrounds the base of *T. matsutake* basidiocarps. Here, several questions, "How and what *T. matsutake* mycelia help the root of *Pinus densiflora*" were arisen. The more works would be needed for the ectomycorrhizal relationships of *T. matsutake* with the roots of *P. densiflora*.

Problems: The pine-mushrooms were harvested from the communities of *P. densiflora* and should be related to the roots of pine trees. As previously mentioned, the relationships of the pine-mushrooms to pine tree were termed "ectomycorrhizae". However, symbiotic relationship between them was not found nor speculated as based on this experiment, but slightly parasitic relationship between them was found because the pine-mushrooms was considered to utilize the energy sources from the pine tree. This observation was referred by Ogawa's researches (Ogawa, 1977b; 1977c; 1977d; 1978; 1979), and would be also revealed in the futher studies.

Productions of the pine-mushrooms contributed to the local economy of farmers around the eastern coast areas in our country. There were two kinds of serious problems for the productions of pine-mushrooms: The pine gall midge epidemically infect and kill the pine trees over all countries (이, 1990), and *Pinus rigida* was nation-wide introduced in the mountains of Korea and compete with Korean habited pine trees (이, 1989). These two events, known to the serious problems, maybe, be considered to kill the pine trees, and ecologically drive the succession of other dominant trees in the communities of pine tree habited at the whole mountains in Korea. Productions of the pine-mushrooms was decreased and finally ceased unless a new inovations was found for two problems. In this regarding, isolations or studies of the pine-mushrooms would be considered to be a great contributions for our national economy and preservation of mountain communities. This conclusion was based on my five year and tedious work and reviewed on the previous studies.

適 要

경상도지역의 송이 생산지 5 곳, 53 site(shiro; 송이울)를 방문하였다. 송이생산지로써 알려진 곳들에 대한, 물리적 및 생태학적인 차이점을 비교한 결과, 일본의 송이 생산지와는 거의 동일한 면이 있었으나, 소나무연령 및 understory flora 에 대한 차이점이 발견되었다. 우리나라의 송이 생산지는 크게 나누어 볼 때 내륙지방과 해안지방으로 나누어지며, 이의 생태학적인 차이점이 파악되었다. 송이울 별 관찰에서는 3가지의 특이한 종류의 흙이 관찰되었으며, 특히 해안지역의 송이울은 일본보고와는 큰차이점이 발견되었다. 우리나라의 송이는 소나무(적송)의 뿌리와 관련이 있으나, 아직 ectomycorrhizae라는 확신은 하지 못하였다. 각각의 송이울에서 분리된 송이균사는 생화학적인 혹은 배양적인 방법으로 구별을 시도하였으나, 송이균사에 대한 확증적인 어떤 특징을 찾기가 어려웠다. 이들에 대한 연구방법 및 송이 생산에 미치는 여러가지 고찰하였다.

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