Abstract

The development of endophytic fungi for biocontrol cantaloupe disease and promote growth. Diseases of cantaloupe were surveyed in Phayao province. It was found that the major diseases were gummy stem blight caused by *Stagonosporopsis cucurbitacearum* and wilt disease caused by *Fusarium equiseti*. The ability to inhibit the pathogenicity of both causal pathogens by endophytic fungi was investigated. *Trichoderma lentiforme* (L1 I3) has an inhibitory effect on fungal pathogens. The highest inhibition was 81.00% to 90.66%. After that, promotion of growth and biocontrol of disease were tested in greenhouse. It was found that the use of *T. lentiforme* (L1 I3) + *S. cucurbitacearum* (treatment 4) could promote growth and good postharvest quality. Biocontrol formulation of *T. lentiforme* was studied by using a mixture of vermiculite and glutinous rice flour. Found that, ratio of 7: 3 (vermiculite: glutinous rice flour) had the highest survival rate of spore at all concentration levels. Preservation of the product at temperatures of 30, 37 and 45 °C having the best survival rates of 33.75×10^3, 35.25×10^3 and 34.75×10^3 spores/milliliter, respectively. The pelleted products tested for their ability to promote the growth of cantaloupe in the field showed that treatment of *T. lentiforme* and *T. harzianum* showed highest plant height (171.20 and 169.00 cm, respectively). Average number of leaves per tree was found that treatment of *T. harzianum* had the highest number of leaflets at 31.38, followed by *T. lentiforme* with 29.00 leaves, but no statistically significant difference. The use of pellet products from *T. lentiforme* will promote growth of cantaloupe and equivalent to the use of commercial pellets from *T. harzianum.*

Storage disease of rice seeds causes severe loss of seed quality and fertility. Here, we aim at evaluating biotechnological benefits of herbicide-resistant endophytic bacteria to recover the health of diseased rice seeds by biopriming technique. Five among all isolates of herbicide-resistant endophytic bacteria gave the best antifungal potential against a set of phytopathogenic fungi isolated from diseased rice seeds. These endophytic bacteria were strains of the genus *Bacillus* classified by phylogenetic analysis of their 16S RNA gene sequences. Biopriming technique comprised of soaking infected rice seeds in the cell suspension of the best herbicide-resistant endophytic bacteria at different time series, followed by air drying till the moisture dropped <12% and keeping at 4°C for 6 months before tests. Non-priming and priming of rice seeds with sterile distilled water served as controls. We found that biopriming could enhance the

germination rate of diseased rice seeds. Full-scale pot tests since germination to production phases after biopriming also optimized growth of rice seedlings lead to the higher yield of rice compared to the controls. With these findings, our biopriming protocol would be a promising green technology for recovering and maintaining the quality and fertility of diseased seeds for further use in organic agriculture with the acceptable crop yield.

The isolation of actinobacteria obtained from spores of *Funneliformis mosseae* and provides evidence for their potential in agricultural uses as plant growth promoters *in vitro* and *in vivo*. Actinobacteria were isolated from spores of *F. mosseae* using the dilution plate technique and media designed for the selective isolation of members of specific actinobacterial taxa. Six strains namely 48, S1, S3, S4, S4-1 and SP, were isolated and identified based on16S rRNA gene sequences. Phylogenetic analysis showed that isolate SP belonged to the genus *Pseudonocardia* with *P. nantongensis* KLBMP 1282^{T} as its closest neighbor. The remaining isolates belonged to the genus *Streptomyces*. Two isolates, 48 and S3 were most closely related to *S. thermocarboxydus* DSM 44293^{T}. Isolates S4 and S4-1 shared the highest 16S RNA gene similarity with *S. pilosus* NBRC 127772^{T}. Isolate S1 showed its closest relationship with the type strain of *S. spinoverrucosus* NBRC14228^{T}. The ability of these isolates to produce indole-3-acetic acid (IAA), siderophores and the ability to solubilize phosphate in vitro were examined. All isolates produced siderophores, four isolates produced IAA and two isolates solubilized inorganic phosphate at varying levels. *S. thermocarboxydus* isolate S3 showed the highest IAA production with high activities of phosphate solubilization and siderophore production. The inoculation of mung beans (*Vigna radiata*) with this strain resulted in a significant increase in fresh weight, root length and total length as an effect of IAA production. In an experiment with rice (*Oryza sativa* KDML105), *S. thermocarboxydus* isolate S3 promoted the growth of rice plants grown in low nutritional soil under induced drought stress. This report supports the view that the inoculation of rice with plant growth promoting actinobacteria mitigates some adverse effects of low nutrient and drought stress on rice.

The selection of effective bacteria that produced high amounts of IAA and ammonia, and determination of the potential of using agar compared with alginate and perlite as cell immobilization materials to maintain a long survival of the inoculant strains were studied. The *Sinorhizobium* spp. strains 2LP20, 2NK9, and *Bacillus* sp. strain

2NK17 were selected, immobilized and stored at 30 °C for 15 days. After 15 days of storage, *Sinorhizobium* sp. strain 2LP20 immobilized in agar exhibited the highest number of bacterial survivals which was significantly different from those of other materials. In pot experiments, the establishment and activity of the inoculant after 15 days of introducing into soil were investigated by PCR-denaturing gradient gel electrophoresis (DGGE) and Reverse Transcription (RT) PCR-DGGE. Cloning and sequencing of 16S rRNA gene fragments obtained from DNA- and RNA-based DGGE gels confirmed that agar and alginate were the preferable immobilization materials that prolonged the survival times and supported the establishment of the inoculant after being introduced into soil rather than absorption in perlite. The inoculant immobilized in agar and alginate were still metabolically active after 15 days of introducing into soil, while usage of perlite as a carrier and liquid inoculation were proved ineffective in maintaining the activity of the inoculant. Moreover, inoculation with either immobilization material exhibited the potential to change bacterial community structure in soil. Moreover, this study we also found *Streptomyces jietaisiensis* strain A034 that able to produce high amounts of IAA and ammonia as well capable of producing anti-nematode substance. We were assessed the effects of *S. jietaisiensis* strain A034 on biocontrol of root knot disease in chili were. The impact of the strain on soil bacterial community and the establishment of the strain after being introduced into the root knot nematode (RKN) infested soils were also investigated. The strain significantly reduced numbers of egg masses by 2.70 to 10.67-fold and decreased numbers of J2 of *Meloidogyne incognita* in the RKN infested soils by 27.79% to 33.85%. The strain significantly increased biomass, shoot and root length by 53.44%, 10.24% and 100%, respectively. Inoculation of the strain significantly increased plant elements including total N, P, K, Ca, Mg and Fe (38.01%, 8.80%, 17.90%, 44.28%, 48.22% and 62.84%, respectively). DNA-based analysis revealed that the strain was capable of surviving and proliferating in the RKN infested soils throughout a cultivation period as well as friendly to microbial community.

Upland rice or aerobic rice always encounter with phosphorus deficiency. Due to acidity or alkalinity of the soil, phosphorus can also fix with other elements and become in unavailable form. The utilization of *Acinetobacter baumannii* strain CR 1.8 and *Bacillus subtilis* strain MC 21 which they are phosphate solubilizing microbes, phosphate become in available forms for plant uptake. This approach may increase rice yield. Therefore, this research was aimed to investigate the host specificity between rice

genotypes and group of P uptake promoting microbes, to compare the bacterial phosphate solubilizing ability in different phosphorus forms, and to get the appropriated method for using the P uptake promoting microbe under rice aerobic cultivation. The responses in growth of 2 rice cultivars as Sew Mae Jan (SMJ) and Khao Dok Mali 105 (KDML 105) were compared in unavailable ($Ca_3O_8P_2$: Ca-P) and available (KH_2PO^4: K-P) phosphorus form soils. It was found that there were 3 groups as group 1 and 3 responses on the interaction effects of rice cultivar and treatment. The group 2 was affected by available phosphorus form which they are solubilized by CR 1.8 and MC 21, resulting in significantly increase in shoot and root elongation, number of root and leaf greenness. The phosphate solubilizing bacterial utilization stimulated rice growth. The spraying *Bacillus subtilis* strain MC 21 on the rice seed germinating stage clearly promoted the rice root growth at 21 days. Moreover, it was found that the specific between microbe and rice cultivar may have the host specificity as clearly in 20 rice cultivars study. Twenty rice cultivars include of local, lowland and upland rice cultivars, they were grown under low phosphorus soils (pH 3.8) and sprayed by *Bacillus subtilis* strain MC 21 suspension. It was found that most rice growth characteristics were affected by rice cultivar effects excepted in root dry matter of rice at 28 days after germination. The effects of bacterial utilization were found in above ground responses. The rice plant grown under control treatment (no microbe) had higher in shoot length, leaf number per plant, leaf greenness and shoot dry matter than the rice plants grown under *Bacillus subtilis* strain MC 21 spraying treatment. The results concluded that there was the host specificity between rice cultivar and phosphate solubilizing bacterial isolate and the bacterial spraying on the rice seed at germination stage was effective method. Therefore, the efficiency of phosphorus promoting bacterial utilization both in host specificity and application method should be basic investigated in each rice cultivar and microbe species.

Moreover, rice (*Oryza sativa*) variety Riceberry is a highly nutritious black rice. It is increasingly popular among consumers. Riceberry rice is susceptible to leaf spot disease caused by *Curvularia lunata* that has effects on decreasing rice yield. Objective of this study was to select effective endophytic bacteria associated with rice plants for promoting the growth and suppressing leaf spot disease of Riceberry rice. A total of 151 endophytic bacteria were isolated from roots, stems, leaves and seeds from rice varieties grown in Chiang Mai Province. Nineteen isolates of the endophytic bacteria could inhibit the growth of *C. lunata*. The most effective endophytic bacterial was *Bacillus* MLL04

that could inhibit spore germination and destroyed mycelium of *C. lunata*. *Bacillus* MLL04 could also induced systemic resistance (ISR) in Riceberry rice. For investigation of phosphate solubilization, 18 isolates of the endophytic bacteria could solubilize rock phosphate. Furthermore, 22 isolates of the endophytic bacteria were capable of producing Indole 3-acetic acid (IAA). Five isolates of the endophytic bacteria which produced high IAA were used in pot experiment for growing Riceberry rice in a greenhouse. The results showed that the Riceberry rice inoculated with the selected bacteria had shoot dry weight higher than the uninoculated plants. The results from this research indicated that the selected endophytic bacteria could be used to promote growth and control leaf spot disease of Riceberry rice plants.

Selection of orchid mycorrhizal fungi from orchid roots was performed for promote the seed germination of orchid. The *Rhizoctonia*-like fungi are common orchid mycorrhizal fungi in orchid roots, especially terrestrial orchids. Previous studies reported that most of *Rhizoctonia*-like fungi could promote orchid seed germination and protocorm development. In this study, a total of 263 fungal isolates were isolated from 24 terrestrial orchid root samples. The selected fungi were classified as *Rhizoctonia*-like fungi (8 isolates) base on morphological characterization and phylogenetic analysis, including group of *Ceratobasidium* sp. CMU-CR1 (2 isolates: CMU-CR11, CMU-CR12) group of *Ceratobasidium* sp. CMU-CR2 (2 isolates: CMU-CR21, CMU-CR22) and group of *Tulasnella* sp. CMU-CR4 (4 isolates: CMU-CR41, CMU-CR42, CMU-CR43, CMU-CR44), were the new species and designated that *T. phuhinrongklaensis* (under reviewed). The plant growth promoting potentials of *Rhizoctonia*-like fungi were determined. The results showed that all of fungal isolates lacked the abilities of indole-3-acetic acid (IAA) production, siderophore production and phosphate solubilization, except *Tulasnella* sp. CMU-CR41 could produce IAA as 23.06 µg/ml. Moreover, *Tulasnella* sp. CMU-CR41 could enhance seed germination of terrestrial orchid, *Epipactis flava*, reached to stage3 (13.28±2.97%) when compared with control (3.47±1.86%). However, *Tulasnella* sp. CMU-CR41, *Ceratobasidium* sp. CMU-CR11 and *Ceratobasidium* sp. CMU-CR21 could not promote seed germination of other orchid species, *Habenaria dentata*, *H. lindleyana*, *Vanda pumila* and *Dendrobium dixanthum*. The optimization of selected fungi on potting media for orchid seedlings growth were investigated. Perlite which was soaked in malt extract broth (MEB) and adjusted moisture content 60–75%, was the most suitably

potting medium of both *Ceratobasidium* sp., whereas *Tulasnella* sp. CMU-CR41 was vermiculites.

According to the study in the Research-Team Association Grant (RTA5580007), a total of 226 actinomycete strains were isolated from the samples and four strains of CMU-NKS-3, CMU-NKS-5, CMU-NKS-17 and CMU-NKS-70 obtained from the Sustainable Development of Biological Resources (SDBR) Laboratory, Chiang Mai University, for screening their activities against oil palm pathogens, *Ganoderma boninense* causes basal stem rot disease. Twenty-four isolates showed more than 60% inhibitory activity, whilst 5 isolates showing the highly antagonistic effect (> 80% inhibition) towards *G. boninense.* The morphological, chemotaxonomic and 16S rRNA gene sequence data revealed that the antagonistic strains belonged to *Streptomyces rapamycinicus* (6 isolates), *S. corchorusii* (1 isolate), *S. sioyaensis* (1 isolate), *S. abikoensis* (1 isolate), and un-identified species of the genus *Streptomyces* (14 isolates) and *Pseudonocardia* (1 isolate) since they were found to be quite different from the close relatives. They have insufficient data to confirm their taxonomic positions or exhibited 16S rRNA gene sequence similarity below the threshold (<98.7%) for species discrimination, consequently, might be considered as new species. Based on DNA-DNA hybridization and multilocus gene analyses, three strains CMU-AB204, CMU-AB225 and CMU-NKS-70 classified as novel species, for which the name of *Streptomyces palmae* sp. nov., *Streptomyces venetus* sp. nov. and *Pseudonocardia thailandensis* sp. nov. are proposed, respectively. Furthermore, *S. palmae* CMU-AB204^{T} was selected to investigate bioactive metabolites production, eight compounds obtained from crude ethyl acetate extract and their structure was elucidated by HR-MS, ^{1}H, ^{13}C and 2D NMR spectra. This strain produced various antimicrobials which assigned as actinopyrone A (**1**), anguinomycin A (**7**), leptomycin A (**8**) and four new phenyl alkenoic acids (**2**, **3**, **4** and **5**) with a mixture (**6**) of two new related structures. The best antifungal in this study was observed in leptomycin A, it had a potential to be an antifungal agent for suppressive the growth of *G. boninense* causing basal stem rot disease in oil palm.

Evaluation of phytochemical constituents and biological activities of *Cuscuta* sp. was studied. *Cuscuta reflexa* grown on five different hosts, *Coccinia grandis*, *Dimocarpus longan, Ficus racemosa*, *Samanea saman* and *Streblus asper*, and *Cu. chinensis* grown on weed, were extracted with methanol, acetone and ethyl acetate. These extracts were examined, along with their antidiabetic and antioxidant activities. The highest level of

total flavonoids (168.48 mg QE/ g extract) and total phenolic content (120.79 mg GAE/ g extract) were observed in the extract of *Cu. chinensis* that was grown on weed. Moreover, the extract also possessed the greatest antioxidant activity (DPPH; IC50 154.49 µg/mL, FRAP; 44.22 mg GAE/ g extract). The HPLC results showed the presence of gallic acid, catechin, vanillic acid, rutin and quercetin in all *Cu. reflexa* samples. Whereas, quercetin, kaempferol and isorhamnetin were detected in *Cu. Chinensis*. Moreover, the GC-MS results showed that various types of phenolic compounds, hydrocarbons, saturated fatty acids and methyl ester of fatty acids, unsaturated fatty acids and methyl ester of fatty acids, vitamin E, terpenes and sterol contained in the extracts of *Cu. reflexa* were capable of being grown on five hosts. Additionally, the extract of *Cu. reflexa* that was grown on *Co. grandis* represented the highest antidiabetic activity with a percent inhibition of 51.2, while the ethyl acetate extract of *Cu. chinensis* possessed the antidiabetic activity with a percent inhibition of 42.38. The results from this study are likely to be applied for utilizing parasitic plant in the production of bioactive compounds for food and cosmetic fields.

Fungi and mushrooms are important in the ecosystem, environment, foods and medical products. There were a several reports on fungi that could produce enzymes or volatile organic compounds which had the antibiotic properties. However, the properties normally depend on the species or strain of the fungi. Different conditions could also make the different compounds producing patterns. Therefore, we were interested in studying of fungi to be the alternative source producers. In the study of enzyme producing on solid media of selected fungi, we found that *Clitopilus doimaesalongensis* could produce cellulase xylanase amylase pectinase. A mushroom *Agaricus subrufescens* had the different patterns of producing linocellulytic enzymes in the different compost media. It also depended on the strains of the mushroom and the enzymes. In the study of antioxidant assay using DPPH, found that *C. doimaesalongensis* and *Auricularia thailandica* could produce some antioxidants. In the study of volatile organic compounds (VOCs) using Disk Sorptive Extraction Based on Monolithic Material and Gas Chromatography-Mass spectrometry (GC/MS), we found that *Pseudocolus fusiformis* could mainly produce the VOCs in the stage of fruiting body forming. VOCs which composed of sulfur were not detected in the stage of egg from of the mushroom. In the study of antibacterial growth, we found that several fungi could inhibit selected bacteria, such as *C. doimaesalongensis*, *Xylaria psidii* (SDBR-CMU308) and *Xylaria* spp. But *A.*

thailandica could not inhibit the bacteria. In the study of effect of media to mycelium growth, we found that best media was Oat Meal Agar for our selected fungi. Studying of identification and purofocation of the bioactive compounds is interesting for the future study.

Utilization of agricultural wastes for high efficiency thermo-lignocellulolytic enzymes production was studied in semi-solid-state fermentation processes of fungi. Agricultural biomass is composed of a high content of lignocellulosic materials. *Thermoascus aurantiacus* SL16W can produce lignocellulolytic enzymes such as cellulase, xylanase, and also phytase at high temperature conditions by utilization of agricultural wastes. In this study, *T. aurantiacus* SL16W was cultivated in pre-treated and non-pretreated of 7 agricultural wastes including, corn cob (CC), corn husk (CrH), bamboo pulp (BP), soybean husk (SH), palm residue (PR), green tea (GT) and rice straw (RS, for 7 days at 45°C under semi-solid-state fermentation. As a result, the cellulase activity from *T. aurantiacus* SL16W on a pretreated soybean husk as a substrate was found to be 36.4 U/g substrate and a xylanase activity on non-pretreated soybean husk was at 389.8 U/g substrate. The phytase activity from *T. aurantiacus* SL16W on non-pretreated soybean husk as a substrate was at a level of 25.7 U/g substrate. The high enzyme activities were found in the mixed substrate of non-pretreated soybean husk and palm residue (4:1) when compared with non-pretreated soybean husk. Moreover, the effects of carbon and nitrogen sources were also determined. Xylose, galactose and D-psicose could enhance cellulase activity of 71.2, 69.1 and 67.1 U/g substrate, respectively. Whereas, the highest xylanase activity was found when galactose was used as inducer (371.6 U/g substrate). On the other hand, lactose and ribose exhibited phytase activity of 47.1 and 46.8 U/g substrate, respectively. The results from this study are likely to be applied for reducing soybean husk and palm residue and could be a potential application in the production of enzyme for animal feed.

Petroleum-based plastic is not biodegradable and becomes a big world problem in nowadays. Because of a lot of plastic consumption and tend to increase in the future, many biotechnology researchers are interested to invent the new brand biodegradable plastic for consumption instead of petroleum-based plastic. Bioplastic can absolutely degrade by microorganisms and release organic compound. In this study focuses on the topic of Polyhydroxybutyrate (PHB) the most found bioplastic in nature by accumulating in bacteria granule and using agricultural waste to be substrates in production. Bacteria

were isolated from composted soil, screened by cultured in medium contained corncob, and selected for PHB production by Nile red method. The best isolate was identified by biochemical and molecular technique, optimized for the best condition of PHB production and used in production process to make the highest quantity of PHB using agricultural waste as a carbon source.

Twenty-five basidiomycetous fungi strains in seven families were studied the degradation of bioplastic of polyhydroxyalkanoate (PHA). Six culture media formulas of (1) 2% malt extracted, (2) 2% malt extracted mixed 4% glycerol, (3) 4% glycerol, (4) 4% glucose, (5) 2% cellulose and (6) 3% straw were prepared to investigate on the growth mycelia for screening of basidiomycetous fungi. Seven strains of *Coprinus radians*, *Coprinus tuberosus*, *Phanerochaete chrysosporium* (dikaryotic), *Phanerochaete chrysosporium* (monokaryotic), *Lentinus tigrinus*, *Trametes versicolor* and *Agrocybe aegerita* were intensively selected to study further of PHA degradation due to their growth ability on several culture media more than 2 differential media formulas. Then the selected basidiomycetous fungi strains were investigated the fungal degradation of PHA under unusual condition (minimal salt medium) by adding polyhydroxybutyrate (PHB) as a sole carbon source and observed the mycelium growth in minimal salt medium without PHB (control) and contained PHB (sample) for 21 days. Only three fungi, (1) *Coprinus radians* (2) *Phanerochaete chrysosporium* (monokaryotic) and (3) *Phanerochaete chrysosporium* (dikaryotic) could notice the growth with large mycelium colony under unusual PHB liquid medium condition. UV-vis spectroscopy, Fourier-transform infrared spectroscopy (FTIR) and gas chromatography were used to determine the amount of PHB from the liquid media during the growth period. The results showed the decreasing of PHB content, especially gas chromatography result confirmed the 72% loss of PHB in liquid medium after 7 days. PHA films of PHB and poly(hydroxybutyrate-*co*-valerate) (PHBV) films were prepared and taken into consider on the model of fungal degradation on minimal salt agar. The SEM results showed that after 21 days the surface of PHB and PHBV films became rough and big porous after degradation. The fungal mycelium of *Cop. radians* could grow on the surface of PHB and PHBV films. Interestingly, it means that the basidiomycetous fungi of *Cop. radians*, might be considered as the alternative microorganism for bioplastic degradation.

In the study of Diversity of Boletes in the northern and northeastern Thailand, several interesting boletes were found. Some of them were carefully studied and

recognized as new species or new report for Thailand. They have been published in the international journals including 1. "*Pulveroboletus fragrans*, a new Boletaceae species from Northern Thailand, with a remarkable aromatic odor" in "Mycological Progress" 2. "First record of *Albatrellus* (Russulales, Albatrellaceae) from Thailand" in "Phytotaxa" 3. "Phylogenetic affinities of the sequestrate genus *Rhodactina* (Boletaceae), with a new species, *R. rostratispora* from Thailand" in "MycoKeys". Moreover, a manuscript of three new *Phylloporus* species has already been submitted to the journal "Mycological Progress" in the title "Three new *Phylloporus* species from tropical China and Thailand". For the other studies including the new genera *Niveopilus* nom. prov., *Chromatophyllum* nom. prov., *Pseudoborofutus* nom. prov. and new species in the genus *Sutorius* are in progress.

Bolete diversity was studied in Chiang Mai Province, Thailand at two community forests of Ban Pang Bong, Doisaket District and Ban Pang Ma O, Chiang Dow District (June-July 2014 and 2016) and the specimens of Doi Suthep-Pui National Park (May–November 2005 and 2006) which collected at the Sustainable Development of Biological Resources Laboratory (SDBR), Faculty of Science, Chiang Mai University. Nighty-two collections were made comprising 63 taxa in the families *Boletaceae*, *Boletinellaceae*, *Gyroporaceae* and *Suillaceae*. Four edible boletes (*Borofutus dhakanus, Chiua viridula*, *Plebopus spongiosus* and *Sutorius obscureumbrinus*) and two small boletes (*Parvixerocomus pseudoaokii* and *Xerocomus nigromaculatus*) are new records of Thailand. Two specimens of *Boletus* sp. and *Heimioporus* sp. may represent new species. While, other 24 morpho-types belong to the genera *Aureoboletus*, *Boletus*, *Boletellus*, *Leccinum*, *Neoboletus*, *Lanmaoa*, *Pulveroboletus*, *Strobilomyces*, *Suillus*, *Tylopilus* and *Rubinoboletus* are awaiting to identify in species level according to some of them are probably the new taxa and need more molecular information. Phylogenetic reconstructions of some selected taxa were conducted using sequences of nrLSU and ITS (13 specimens each) representing eight species of Boletaceae and one Boletinellaceae. Phylogenetic data were strongly correlated with morphological data and were useful to aid in delimiting genera and species, particularly those of the rare or new edible taxa.

Currently, farmers and academics who have plantations or orchards in the northern part of Thailand cultivate *Phlebopus* spp. (Tub Tao). Because of this mushroom has a texture and taste, rich in nutrition and medicinal properties. It is also a mycorrhizal

fungus that helps plants grow well and tolerance to poverty. This study showed that *Phlebopus* spp., which were cultivated with *Elaeocarpus hygrophilus* (Ma Kok Num) in the experimental plots of Huai Hong Khrai Study Center, Chiang Mai Province and Chiang Rai Horticultural Research Center, Chiang Rai Province successfully induced the fruit body of mushroom both in and out of the season by properly sprinkling the water. Especially during the season change.

Species diversity of *Marasmius* in protected areas: Khao Yai National Park; Doi Suthep-Pui National Park; Phu Hin Rong Kla National Park and Romklao Botanical Garden under the Royal Initiative, Phitsanulok Province; was studied. One hundred and sixty samples were collected during 2006-2013 and 2016-2018. Based on morphological and anatomical characters, 4 sections (*Globulares, Marasmius, Neosessiles* and *Sicci*) were classified and represented 52 taxa. Phylogenetics analyses based on ITS sequences indicated that at least 8 species of *Marasmius* found from this study are new species candidate.

A total 40 samples of ectomycorrhizal (ECM) fungi and 15 samples of saprotophic fungi were collected in northern Thailand. Three spices of ECM fungus, *Gyrodon suthepensis*, *Tuber thailandicum* and *Tuber lannaense* were found. *Cantharocybe virosa, Gymnopilus dilepis, Singerocybe alboinfundibuliformis* were the new report in Thailand. A pure culture of *Pisolithus orientalis* was isolated from fruiting boidy. This fungus was investigated the suitable mycelial growth conditions of this fungus and its ability to form ectomycorrhizal symbiosis with seedlings of *Eucalyptus camaldulensis* and *Pinus kesiya in vitro*. The fungal mycelium grew well on Murashige and Skoog medium that was adjusted to pH 5.0 at 30 °C. The plant seedlings were inoculated with fungal mycelium. The mycorrhization was first observed on pine and eucalyptus at 10 and 12 weeks after inoculation, respectively. Moreover, the identification of mycorrhizal association was confirmed by molecular methods. This is the first report of pure culture synthesis of *Pis. orientalis* mycorrhizae and the compatible of mycorrhizal formation of *E. camaldulensis*.

Keyword: Microbial diversity, plant growth promoting, biocontrol, microbial enzyme, biodegradation,