

germination of the fungal pathogen compared to single treatment of ozonation or photocatalysis. The efficient control of fungal spoilage and degradation of residual fungicide on kiwifruits indicate that TiO₂ photocatalytic ozonation is a very attractive method for postharvest disease control of kiwifruits as an alternative to fungicides application.

2-04. Development of biological agent seeded on fine sand for control of brown patch and Pythium blight disease on golf course grasses.

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Antagonistic bacteria against *Rhizoctonia solani* and *Pythium* spp., causing serious damage to golf course grasses, were isolated from the top soil of several golf courses in Korea. The isolate of Limk0102 was selected as the biological agent by characterization of antifungal activity, large scale preparation, fungicides tolerance and ecological fitness to the target environment. The isolate was identified as *Bacillus subtilis* by biochemical and physiological characterization, and 16S rDNA sequence analysis. The bacterial agent was formulated as a granule type by seeding it on fine sand. The formulated agent showed high recovery rate (more than 10⁸ cells/g sand) even after 6 month-storage at room temperature with similar antifungal activity with that of original cells. *In vitro*, the biological agent successfully exhibited antagonistic performance on bentgrass inoculated with *R. solani* or *Pythium* spp. isolated from the diseased grasses on golf courses. Field evaluation on disease control activity and ecological fitness of the agent is now under going on several golf courses.

2-05. Changes in sensitivity to metalaxyl of *Phytophthora infestans* in Korea.

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Changes of control efficacy of metalaxyl to potato late blight caused by *Phytophthora infestans* were examined in potato fields from 2001 to 2003. In 2001 and 2002, control efficacy of metalaxyl was similar to those of dimethomorph and etaboxam. However, the control efficacy of metalaxyl were decreased to 50.3% in 2003. Total 366 isolates of *P. infestans* obtained from several areas in Korea from 2001 to 2003 were examined for changes of sensitivity to metalaxyl. About 6.8% of fungal isolates examined in 2001 were sensitive, 84.1% were intermediate resistant, 9.1% were resistant to metalaxyl. Among the isolates collected in 2002, 3.9% were sensitive, 75.6% were intermediate resistant, 20.6% were resistant to the chemical. However, among the isolates obtained in 2003, 55.9% were intermediate resistant, 44.1% were resistant, but none of the isolates tested were sensitive. Both A1 and A2 mating type isolate were isolated in 2002~2003. However, all

isolates collected in 2001 were A1 mating type. About 87.5% of the isolates collected in 2002, 89.8% in 2003 were determined as A1 mating type. The majority of the *P. infestans* isolates were A1 mating types. Changes of control efficacy of metalaxyl to potato late blight might be caused by the occurrence rate of moderately resistant isolates within A1 mating type.

2-06. Effects of ectomycorrhizal fungi on soil-borne plant pathogenic fungi in red pine seedlings

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Disease suppression by ectomycorrhizal (ECM) fungi has been demonstrated on red pine seedlings. Culturing of pathogenic fungi on petri plates containing culture filtrates of ECM fungi showed that culture filtrates of the ECM fungus *Hebeloma cylindrosporum* may inhibit the mycelial growth of all tested soil-borne plant pathogenic (SBPP) fungi upto 60%. In order to examine the effects of ECM fungi on SBPP fungi and on red pine seedlings, both symbiotic and pathogenic fungi were inoculated into the soil with red pine seedlings by three inoculation methods; pre-inoculation of SBPP fungi 10 days before inoculation of ECM fungi, simultaneous inoculation of both fungi, post-inoculation of SBPP fungi 60 days after inoculation of ECM fungi. Seedling mortality, seedling growth, and ectomycorrhizal formation by the combined treatments were examined and compared. Pine seedlings were dead by the pre-inoculation of pathogenic fungi, except *Rhizina undulata* which required 9-12 days, within 6 days after inoculation. Among pathogenic fungi tested, *Fusarium oxysporum* was the most pathogenic with the mortality of 44%. However, no dead seedlings were shown by simultaneous inoculation of both fungi or pre-inoculation of ECM fungi. In addition, pine seedlings treated by simultaneous or post-inoculation of SBPP fungi were relatively higher than those treated by pre-inoculation in diameter at root crown and the number of ectomycorrhizal roots. There were no significant differences among inoculation methods in root length and dry weight of treated seedlings. It means that ECM fungi somehow play a role in protecting primary roots of red pine seedlings against invasion by the SBPP fungi.

2-07. Evaluation of fungicides to control of potato late blight in Korea

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Potato late blight, caused by *Phytophthora infestans*, is one of the important diseases in potato cultivation areas. Though the incidence of late blight was depend on the inoculums and climatic condition in each fields, the foliar blight was reached to 100% under the severe disease pressure condition in 2003. Outbreak of foliar blight was concentrated from May and July and evaluation of ten fungicides to control of late blight was made at Daekwallryoung area in potato