Chemical and biological agents were evaluated to inhibit *Colletotrichum fructicola*, *Phytophthora cactorum*, and *Lasiodiplodia theobromae* causing strawberry diseases. Mycelial growths of *C. fructicola* were gradually arrested by increasing concentrations of fungicides pyraclostrobin and iminoctadine tris (albesilate). *P. cactorum* and *L. theobromae* were more sensitive to pyraclostrobin compared to *C. fructicola*, but iminoctadine tris (albesilate) was not or less effective to limit *P. cactorum* or *L. theobromae*, respectively. *Bacillus siamensis* H30-3 was antagonistic against the three pathogens by diffusible as well as volatile molecules, and evidently reduced aerial mycelial formation of *P. cactorum*. *B. siamensis* H30-3 growth was declined by at least 0.025 mg/ml of pyraclostrobin. The two fungicides additively inhibited mycelial growths of *C. fructicola*, but not of *P. cactorum* and *L. theobromae*. *B. siamensis* H30-3 volatiles led to less growth of *C. fructicola* than one reduced by the fungicides. Taken together, in vitro antimicrobial activities of the two fungicides together with or without *B. siamensis* H30-3 volatiles may be cautiously incorporated into integrated management of strawberry diseases dependent on causal pathogens.

**Keywords** : antimicrobial, *Bacillus siamensis*, fungicides, strawberry diseases, volatiles

**Handling Editor** : Youn-Sig Kwak

Strawberry production worldwide is strained by *Colletotrichum* and *Phytophthora* species. Strawberry anthracnose by *Colletotrichum* spp. has been serious threat and various controls including chemical fungicides were suggested. *C. fructicola* is a part of *C. gloeosporioides* species complex, and DNA markers were developed to differentiate the fungal species from other *Colletotrichum* spp. causing strawberry anthracnose (Gan et al., 2017). Many Korean *C. gloeosporioides* isolates causing strawberry anthracnose was re-classified as *C. fructicola* (Nam et al., 2013). Fungicides azoxystrobin and prochloraz-Mn protected strawberry crown anthracnose by dipping the seedlings in fungicides before planting in fruit production fields (Kim et al., 2002; Nam et al., 2014). Control efficacies of azoxystrobin, pyraclostrobin and thiophanate-methyl as protectants were found in strawberry plant fields over 3 years against *C. gloeosporioides*–causing crown rot (MacKenzie et al., 2009). *Phytophthora cactorum* infection led to leather rot and crown rot of strawberry (Grove et al., 1985; Lim et al., 1998; Madden et al., 1991). Azoxystrobin, mefenoxam, and pyraclostrobin showed protectively controlled strawberry leather rot, whilst post-infection treatment with mefenoxam only decreased the
leather rot (Rebollar-Alviter et al., 2007). Metalaxyl and fosetyl-Al reduced the leather rot by foliar-spraying and soil-drenching in strawberry fruit production fields (Ellis et al., 1998). In South Korea, two and six fungicides were registered to control Phytophthora rot in strawberry nursery and fruit production fields, respectively, in 2020. However, pyraclostrobin and iminoctadine tris (albesilate) were not investigated for the strawberry Phytophthora rot yet.

Lasiodiplodia theobromae infects many plants such as grapevine, mango, and peach trees (Burrano et al., 2008; Li et al., 2014; Saeed et al., 2017; Úrbez-Torres et al., 2008). Strawberry dieback by L. theobromae was reported in nursery of South Korea and fruit production fields in Turkey (Nam et al., 2016; Yildiz et al., 2014). Strawberry cv. ‘Seolhyang’, planted over 80% of production fields in South Korea, was highly susceptible to the dieback, which can be a great concern (Nam et al., 2016). Unfortunately, appropriate controls have not been demonstrated for the strawberry dieback.

Pyraclostrobin controlled anthracnose on strawberry, bean, grape, and pepper plants (Conner et al., 2004; Gao et al., 2017; Samuelian et al., 2014; Turechek et al., 2006). However, recent occurrences of pyraclostrobin-resistant C. acutatum isolates in pepper and strawberry fields warned of frequently using pyraclostrobin (Forcelini et al., 2016; Kim et al., 2019). Iminoctadine tris (albesilate) has shown in vitro antifungal activity against Alternaria dauci causing carrot Alternaria leaf spot and Aspergillus tubingenensis causing Shine Muscat bunch rot (Do et al., 2020; Kim et al., 2020), and protectively and curatively reduced cucumber leaf spots by Corynespora cassicola (Zhu et al., 2019). Iminoctadine tris (albesilate) was registered for strawberry anthracnose and grey mould in South Korea, but hardly demonstrated for other strawberry diseases.

Antagonistic microbes have controlled strawberry diseases. Endophytic bacterium Azospirillum brasilense REC3 in strawberry roots promoted plant growth as well as controlled anthracnose via enhanced plant immunity including augmented phenolics and pathogenesis-related gene expressions in plants (Tortora et al., 2012). Decreased anthracnose by Bacillus amyloliquefaciens S13-3 derived from soil was closely related with the bacterium-produced antimicrobial lipopeptides (Mochizuki et al., 2012; Yamamoto et al., 2015). Dipping strawberry roots in Trichoderma harzianum and T. viride conidial suspensions decreased leather rot (Porras et al., 2007). Pseudomonas fluorescense F113 and Serratia plymuthica HRO-C48 from rhizosphere of sugar beet and oilseed rape plants, respectively, reduced the strawberry root rot (Barahona et al., 2011; Kurze et al., 2001).

Bacillus siamensis H30-3 promoted Chinese cabbage plant growth under normal ambient and adverse environments like high temperature- and high temperature-drought stresses (Lee et al., 2018; Shin et al., 2019). B. siamensis H30-3 was antagonistic to Alternaria brassicicola and Colletotrichum higginsianum causing black spot and anthracnose diseases in Chinese cabbage, respectively, but diseases by A. brassicicola and C. higginsianum were reduced in cv. Ryekokgwang, not cv. Buram-3-ho (Lee et al., 2018). Chinese cabbage soft rot by Pectobacterium carotovorum subsp. carotovorum was alleviated by B. siamensis H30-3 (Shin et al., 2019). These results indicate that B. siamensis H30-3 has broad antimicrobial activities against fungi and bacteria.

In this study, in vitro antifungal activities of two fungicides pyraclostrobin and iminoctadine tris (albesilate) were demonstrated against C. fructicola, P. cactorum, and L. theobromae by singly or simultaneously. B. siamensis H30-3 was applied to the three pathogens to investigate whether the bacterial strain arrests the pathogen growths through diffusible and volatile antifungal machineries. Tolerance of B. siamensis H30-3 to the two fungicides was evaluated for simultaneous usage potentials with chemical controls for integrated strawberry disease management. Simultaneous treatment with two fungicides with or without B. siamensis H30-3 volatiles on the three pathogen growths was also investigated.

In vitro antimicrobial activities of pyraclostrobin and iminoctadine tris (albesilate) were evaluated against C. fructicola, P. cactorum, and L. theobromae (Fig. 1). Colony formation (Fig. 1A) and mycelial growths (Fig. 1B) of C. fructicola were gradually decreased by increasing pyraclostrobin (0, 0.00625, 0.0125, 0.025, 0.05, and 0.1 mg/ml) and iminoctadine tris (albesilate) (0, 0.00625, 0.0125, 0.025, 0.05, and 1 µg/ml). Linear repression analyses demonstrated strong correlation of fungicides concentrations with antimicrobial activities of two fungicides and B. siamensis (Y = –14.79X + 100.59, R² = 0.9689) and iminoctadine tris (albesilate) (Y = –17.308X + 123.71, R² = 0.9689).

Increasing pyraclostrobin concentrations at 0.00625, 0.0125, 0.025, 0.05, and 0.1 mg/ml resulted in significant decreases in mycelial growth of C. fructicola to ca. 56.9%, 50.2%, 42.5%, 28.3%, and 15.2% compared to mock-treated control. Same dosage range of pyraclostrobin showed more drastic suppressions in mycelial growths of P. cactorum and L. theobromae. Minimal concentration of 0.00625 mg/ml of pyraclostrobin reduced growth of P. cactorum and L. theobromae by ca. 18.9% and 17.5%, respectively. More doses of pyraclostrobin to 0.1 mg/ml did not change P.
Antimicrobial Fungicides and Bacteria

Increasing doses to more than 0.025 to 0.1 mg/ml gradually more suppressed the growths of \textit{L. theobromae}. Increasing iminoctadine tris (albesilate) concentrations at 0.00625, 0.0125, 0.025, 0.05, and 0.1 µg/ml led to significant decreases in growth of \textit{C. fructicola} to ca. 89.2%, 78.0%, 62.0%, 34.9%, and 14.6% compared to mock-treated control. Same dosage ranges of iminoctadine tris (albesilate) has no antimicrobial activity against \textit{P. cactorum}, and only slightly reduced growth inhibition was found against \textit{L. theobromae} by 0.05-0.1 µg/ml. These results suggest that pyraclostrobin can be applied to control both Phytophthora rot and dieback caused by \textit{P. cactorum} and \textit{L. theobromae}, respectively. Antimicrobial activities of iminoctadine tris (albesilate) by more than 0.1 µg/ml remains investigated.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{fig1.png}
\caption{In vitro inhibitory efficacies of two chemical fungicides pyraclostrobin and iminoctadine tris (albesilate) on mycelial growths of \textit{Colletotrichum fructicola} isolate SAn-3, \textit{Phytophthora cactorum} isolate P-9815 (KACC 40183) and \textit{Lasiodiplodia theobromae} isolate LT129092. (A) Colony formations of \textit{C. fructicola}, \textit{P. cactorum}, and \textit{L. theobromae} on 1/2-potato dextrose agar media containing different concentrations of pyraclostrobin and iminoctadine tris (albesilate), and cultured at 25°C for 5, 10, and 2 days for \textit{C. fructicola}, \textit{P. cactorum}, and \textit{L. theobromae}, respectively. (B) Relative mycelial growths (%) of \textit{C. fructicola}, \textit{P. cactorum}, and \textit{L. theobromae}. Bars represent the standard errors of the means of the five independent experimental replications. Each experiment has four replications. Means followed by the same letters are not significantly different at 5% level by least significant difference test.}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{fig2.png}
\caption{In vitro inhibition of mycelial growths of \textit{Colletotrichum fructicola}, \textit{Phytophthora cactorum}, and \textit{Lasiodiplodia theobromae} by dual cultures with \textit{Bacillus siamensis} H30-3. (A) Mycelial cultures on 1/2-potato dextrose agar media in the absence or presence of \textit{B. siamensis} H30-3 co-culture at 25°C. Photos were taken 8, 16, and 4 days after inoculation of \textit{C. fructicola}, \textit{P. cactorum}, and \textit{L. theobromae}, respectively. (B) Inhibited mycelial growths shown by half of the colony diameter after co-culture. Bars represent the standard errors of the means of the five independent experimental replications. Each experiment has four replications. Asterisks indicate significant differences as determined by Student’s \textit{t}-test (\textit{P} < 0.05).}
\end{figure}
activities against *C. fructicola*, *P. cactorum* and *L. theobromae* (Fig. 3). Volatiles from *B. amyloliquefaciens*, *B. pumilus* and *B. velezensis* strains showed antifungal activities against diverse fungal species (Asari et al. 2016; Lim et al., 2017; Morita et al., 2019). Reduced colonies of the three pathogens were found on 1/2-PDA media covered different culture media tryptic soy agar, nutrient agar, and Luria-Bertani agar media drop-inoculated by *B. siamensis* H30-3 (Fig. 3A). Particularly, aerial mycelia of *P. cactorum* was drastically reduced by *B. siamensis* H30-3 volatiles. Distinct difference in growth inhibition by the different bacterial media was not found (Fig. 3B).

*B. siamensis* H30-3 has several antimicrobial lipopeptide-encoding genes such as *bacD*, *bmyA*, *ituA*, and *srfA* (Lee et al., 2018), which may be involved in the suppressed *C. fructicola*, *P. cactorum*, and *L. theobromae*. In vitro bactericidal activities of the two fungicides against *B. siamensis* H30-3 were investigated (Fig. 4). *B. siamensis* H30-3 (10⁵ cfu/ml) were initially cultured in 4-ml of nutrient broth with or without increasing concentrations of the two fungicides at 30°C for 24 h and the bacterial growths were evaluated spectrophotometrically at OD 600 (Hong et al., 2016). Bacterial growth was declined by more than 0.025 mg/ml of pyraclostrobin and no change was found by increased doses (0.05-0.1 mg/ml). Iminocycline tris (albesilate) doses from 0.00625 to 0.1 µg/ml has no antibacterial effect on *B. siamensis* H30-3. *Bacillus* spp. as biological control agents were suggested to be integrated into disease management with chemical fungicides (Jacobsen et al., 2004; Korsten et al., 1997; Lee et al., 2012). *B. siamensis* H30-3 can be considered for strawberry disease control with the two fungicides. However, use of less than 0.0125 mg/ml pyraclostrobin will be recommended to avoid its negative effect on the growth of *B. siamensis* H30-3 during their simultaneous application.

Antimicrobial effects of the two chemical fungicides with *B. siamensis* H30-3 volatiles were investigated (Fig. 3).
Fig. 5. Antimicrobial activities of chemical fungicides pyraclostrobin and iminoctadine tris (albesilate) with or without volatiles from Bacillus siamensis H30-3. Mycelial growths of Colletotrichum fructicola, Phytophthora cactorum and Lasiodiplodia theobromae on 1/2-potato dextrose agar (PDA) media supplemented with pyraclostrobin (P) (0.00625 mg/ml) and/or iminoctadine tris (albesilate) (I) (0.00625 µg/ml). The PDA media were covered by tryptic soy agar media inoculated by B. siamensis H30-3. Colony diameters were measured after cultures at 25°C for 5, 10, and 2 days for C. fructicola, P. cactorum and L. theobromae, respectively. Values presented are means and error bars indicated the standard errors of the means of five independent experimental replications. Each experiment has four replications. Means followed by the same letters are not significantly different at 5% level by least significant difference test.

5). Co-treatment with pyraclostrobin (0.00625 mg/ml) and iminoctadine tris (albesilate) (0.00625 µg/ml) without B. siamensis H30-3 volatiles resulted in more significantly suppressed growths of C. fructicola compared to the one treated with single fungicide. However, P. cactorum and L. theobromae was not synergistically suppressed by the co-treatment with the two fungicides. Together with B. siamensis H30-3 volatiles, mycelial growths of C. fructicola were more efficiently decreased by pyraclostrobin and/or iminoctadine tris (albesilate). The fungicide-suppressed P. cactorum was rather relieved by B. siamensis H30-3 volatiles. No significant difference in growths of L. theobromae treated with the fungicides by B. siamensis H30-3 volatiles. It should be solved how B. siamensis H30-3 volatiles will apply to the strawberry growing fields. Identification of B. siamensis H30-3 volatile compounds and improved production of the antimicrobial volatile compounds may pave a way for more efficient and reliable biological control of strawberry diseases.

Taken together, fungicides pyraclostrobin and iminoctadine tris (albesilate) and B. siamensis H30-3 showed their antimicrobial activities against the C. fructicola, P. cactorum, and L. theobromae singly or in combination. Use of B. siamensis H30-3 volatiles with pyraclostrobin and/or iminoctadine tris (albesilate) can be a more useful for controlling strawberry anthracnose by C. fructicola. In planta disease control efficacies of the chemical and biological agents will provide more sustainable production of strawberry fruits.

Conflicts of Interest

No potential conflict of interest relevant to this article was reported.

Acknowledgments

This research was supported by Gyeongnam National University of Science and Technology (GNTech) Grant 2020 to Jeum Kyu Hong.

References

Asari, S., Matzén, S., Petersen, M. A., Bejai, S. and Meijer, J. 2016. Multiple effects of Bacillus amyloliquefaciens volatile compounds: plant growth promotion and growth inhibition of phytopathogens. FEMS Microbiol. Ecol. 92:fiw070.

Barahona, E., Navazo, A., Martinez-Granero, F., Zea-Bonilla, T., Pérez-Jiménez, R. M., Martin, M. and Rivilla, R. 2011. Pseudomonas fluorescens F113 mutant with enhanced competitive colonization ability and improved biocontrol activity against fungal root pathogens. Appl. Environ. Microbiol. 77:5412-5419.

Burrano, S., Mondello, V., Conigliaro, G., Alfonzo, A., Spagnolo, A. and Mugnai, L. 2008. Grapevine decline in Italy caused by Lasiodiplodia theobromae. Phytopathol. Mediterr. 47:132-136.

Conner, R. L., McAndrew, D. W., Kiehn, F. A., Chapman, S. R. and Froese, N. T. 2004. Effect of foliar fungicide application timing on the control of bean anthracnose in the navy bean ‘Navigator’. Can. J. Plant Pathol. 26:299-303.

Do, J., Min, J., Kim, Y., Park, Y. and Kim, H. T. 2020. Detection of fungicidal activities against Alternaria dauci causing
Alternaria leaf spot in carrot and monitoring for the fungicide resistance. *Res. Plant Dis.* 26:61-71 (in Korean).

Ellis, M. A., Wilcox, W. F. and Madden, L. V. 1998. Efficacy of metalaxyl, fosetyl-aluminum, and straw mulch for control of strawberry leaf rot caused by *Phytophthora cactorum*. *Plant Dis.* 82:329-332.

Forcelini, B. B., Seijo, T. E., Amiri, A. and Peres, N. A. 2016. Resistance in strawberry isolates of *Colletotrichum acutatum* from Florida to quinone-outside inhibitor fungicides. *Plant Dis.* 100:2050-2056.

Gan, P., Nakata, N., Suzuki, T. and Shirasu, K. 2017. Markers to differentiate species of anthracnose fungi identity *Colletotrichum fructicola* as the predominant virulent species in strawberry plants in Chiba Prefecture of Japan. *J. Gen. Plant Pathol.* 83:14-22.

Gao, Y.-Y., He, L.-F., Li, B.-X., Mu, W., Lin, J. and Liu, F. 2017. Sensitivity of *Colletotrichum acutatum* to six fungicides and reduction in incidence and severity of chili anthracnose using pyraclostrobin. *Australs. Plant Pathol.* 46:521-528.

Grove, G. G., Madden, L. V., Ellis, M. A. and Schmittchen, A. F. 1985. Influence of temperature and wetness duration on infection of immature strawberry fruit by *Phytophthora cactorum*. *Phytopathology* 75:165-169.

Hong, J. K., Kim, H. J., Jung, H., Yang, H. J., Kim, D. H., Sung, C. H., Park, C.-J. and Chang, S. W. 2016. Differential control efficacies of vitamin treatments against bacterial wilt and grey mould diseases in tomato plants. *Plant Pathol.* J. 32:469-480.

Jacobsen, B. J., Zidack, N. K. and Larson, B. J. 2004. The role of *Bacillus*-based biological control agents in integrated pest management systems: plant diseases. *Phytopathology* 94:1272-1275.

Kim, S.-H., Choi, S.-Y., Lim, Y.-S., Yoon, J.-T. and Choi, B.-S. 2002. Effect of chemical treatment on the control of strawberry anthracnose caused by *Colletotrichum* sp. *Res. Plant Dis.* 8:50-54 (in Korean).

Kim, S., Min, J. and Kim, H. T. 2019. Occurrence and mechanism of fungicide resistance in *Colletotrichum acutatum* causing pepper anthracnose against pyraclostrobin. *Korean J. Pestic. Sci.* 23:202-211 (in Korean).

Kim, Y. S., Kwon, H. T., Hong, S.-B. and Jeon, Y. 2020. Occurrence of bunch rot disease caused by *Aspergillus tubingensis* on Shine Muscat grape. *Res. Plant Dis.* 25:220-225 (in Korean).

Korsten, L., De Villiers, E. E., Wéhner, F. C. and Kotzé, J. M. 1997. Field sprays of *Bacillus subtilis* and fungicides for control of preharvest fruit diseases of avocado in South Africa. *Plant Dis.* 81:455-459.

Kurze, S., Bahl, H., Dahl, R. and Berg, G. 2001. Biological control of fungal strawberry diseases by *Serratia plymuthica* HRO-C48. *Plant Dis.* 85:529-534.

Lee, Y. H., Cho, Y.-S., Lee, S. W. and Hong, J. K. 2012. Chemical and biological controls of balloon flower stem rots caused by *Rhizoctonia solani* and *Sclerotinia sclerotiorum*. *Plant Pathol. J.* 28:156-163.

Lee, Y. H., Jang, S. J., Han, J.-H., Bae, J. S., Shin, H., Park, H. J., Sang, M. K., Han, S. H., Kim, K. S., Han, S.-W. and Hong, J. K. 2018. Enhanced tolerance of Chinese cabbage seedlings mediated by *Bacillus aryabhattai* H26-2 and *B. siamensis* H30-3 against high temperature stress and fungal infections. *Plant Pathol.* J. 34:555-566.

Li, Z., Wang, Y.-T., Gao, L., Wang, F., Ye, J.-L. and Li, G.-H. 2014. Biochemical changes and defence responses during the development of peach gummosis caused by *Lasiodiplodia theobromae*. *Eur. J. Plant Pathol.* 138:195-207.

Lim, S. M., Yoon, M.-Y., Choi, G. J., Choi, Y. H., Kang, J. S., Shin, T. S., Park, H. W., Yu, N. H., Kim, Y. H. and Kim, J.-C. 2017. Diffusible and volatile antifungal compounds produced by an antagonistic *Bacillus velezensis* G341 against various phytopathogenic fungi. *Plant Pathol. J.* 33:488-498.

Lim, Y.-S., Jung, K.-C., Kim, S.-H. and Bark, S.-D. 1998. Crown rot of strawberry (*Fragaria ananassa*) caused by *Phytophthora cactorum*. *Korean J. Plant Pathol.* 14:753-757.

MacKenzie, S. J., Mertely, J. C. and Peres, N. A. 2009. Curative and protectant activity of fungicides for control of crown rot of strawberry caused by *Colletotrichum gloeosporioides*.* Plant Dis.* 93:815-820.

Madden, L. V., Ellis, M. A., Grove, G. G., Reynolds, K. M. and Wilson, L. L. 1991. Epidemiology and control of leather rot of strawberries. *Plant Dis.* 75:439-446.

Mochizuki, M., Yamamoto, S., Aoki, Y. and Suzuki, S. 2012. Isolation and characterization of *Bacillus amyloliquefaciens* S13-3 as a biological control agent for anthracnose caused by *Colletotrichum gloeosporioides*. *Biocontrol Sci. Technol.* 22:697-709.

Morita, T., Tanaka, I., Ryuda, N., Ikari, M., Ueno, D. and Someya, T. 2019. Antifungal spectrum characterization and identification of strong volatile organic compounds produced by *Bacillus pumilus* TM-R. *Heliozyx* 5:e01817.

Nam, M. H., Lee, I. H. and Kim, H. G. 2014. Dipping strawberry plants in fungicides before planting to control anthracnose. *Res. Plant Dis.* 20:54-58 (in Korean).

Nam, M. H., Park, M. S., Kim, H. S., Kim, T. I., Lee, E. M., Park, J. D. and Kim, H. G. 2016. First report of dieback caused by *Lasiodiplodia theobromae* in strawberry plants in Korea. *Mycobiology* 44:319-324.

Nam, M. H., Park, M. S., Lee, H. D. and Yu, S. H. 2013. Taxonomic re-evaluation of *Colletotrichum gloeosporioides* isolated from strawberry in Korea. *Plant Pathol. J.* 29:317-322.

Porras, M., Barrau, C., Arroyo, F. T., Santos, B., Blanco, C. and Romero, F. 2007. Reduction of *Phytophthora cactorum* in strawberry fields by *Trichoderma* spp. and soil solarization. *Plant Dis.* 91:142-146.

Rebollar-Alviter, A., Madden, L. V. and Ellis, M. A. 2007. Pre- and post-infection activity of azoxystrobin, pyraclostrobin, mefenoxam, and phosphite against leather rot of strawberry, caused by *Phytophthora cactorum*. *Plant Dis.* 91:559-564.

Saeed, E. E., Sham, A., AbuZarqa, A., Al Shurafa, K. A., Al
Naqbi, T. S., Iratni, R., El-Tarabily, K. and AbuQamar, S. F. 2017. Detection and management of mango dieback disease in the United Arab Emirates. *Int. J. Mol. Sci.* 18:2086.

Samuelian, S. K., Greer, L. A., Savocchia, S. and Steel, C. C. 2014. Application of Cabrio (a.i. pyraclostrobin) at flowering and veraison reduces the severity of bitter rot (*Greeneria uvicola*) and ripe rot (*Colletotrichum acutatum*) of grapes. *Aust. J. Grape Wine Res.* 20:292-298.

Shin, D. J., Yoo, S.-J., Hong, J. K., Weon, H.-Y., Song, J. and Sang, M. K. 2019. Effect of *Bacillus aryabhattai* H26-2 and *B. siamensis* H30-3 on growth promotion and alleviation of heat and drought stresses in Chinese cabbage. *Plant Pathol. J.* 35:178-187.

Tortora, M. L., Díaz-Ricci, J. C. and Pedraza, R. O. 2012. Production of strawberry plants (*Fragaria ananassa* Duch.) against anthracnose disease induced by *Azospirillum brasilense*. *Plant Soil* 356:279-290.

Turechek, W. W., Peres, N. A. and Werner, N. A. 2006. Pre- and post-infection activity of pyraclostrobin for control of anthracnose fruit rot of strawberry caused by *Colletotrichum acutatum*. *Plant Dis.* 90:862-868.

Úrbez-Torres, J. R., Leavitt, G. M., Guerrero, J. C., Guevara, J. and Gubler, W. D. 2008. Identification and pathogenicity of *Lasiodiplodia theobromae* and *Diplodia seriata*, the causal agents of bot canker disease of grapevines in Mexico. *Plant Dis.* 92:519-529.

Yamamoto, S., Shiraishi, S. and Suzuki, S. 2015. Are cyclic lipopeptides produced by *Bacillus amyloliquefaciens* S13-3 responsible for the plant defence response in strawberry against *Colletotrichum gloeosporioides*? *Lett. Appl. Microbiol.* 60:379-386.

Yildiz, A., Benlioglu, K. and Benlioglu, H. S. 2014. First report of strawberry dieback caused by *Lasiodiplodia theobromae*. *Plant Dis.* 98:1579.

Zhu, J., Zhang, L., Ma, D., Gao, Y., Mu, W. and Liu, F. 2019. A bioactivity and biochemical analysis of iminoctadine tris (albesilate) as a fungicide against *Corynespora cassiicola*. *Pestic. Biochem. Physiol.* 158:121-127.