ABSTRACT

Sheath rot disease of rice, mainly caused by *Sarocladium oryzae* and *Fusarium* spp., is a seedborne threat that significantly reduces seed quality, plant growth, and yield. This study was designed to (i) investigate the impact of *S. oryzae* and *Fusarium* spp. infections on seed quality, plant growth, and rice yield across cytoplasmic male sterile (CMS 19A), hybrid (PDH 08), and inbred (Ciherang) lines; (ii) identify fungal pathogens recovered from seeds and plant tissues using Internal Transcribed Spacer of ribosomal DNA (ITS rDNA) sequencing; (iii) synthesize and characterize silica nanoparticles (SiO_2NPs) from rice husk ash through physical, chemical, and biological methods; and (iv) evaluate the antifungal activity of SiO_2NPs and their role in enhancing plant defense responses to sheath rot disease, particularly through *Oryza sativa Pathogenesis-Related gene 1* (*OsPR1)* gene expression. Symptomatic and asymptomatic seeds from CMS, hybrid, and inbred rice lines were assessed for biochemical profiles, vigor, and viability, and subsequently grown under controlled conditions for growth and yield evaluation. A total of 75 fungal isolates were obtained from leaf sheaths, seeds, and harvested grains; their taxonomic identities were confirmed through ITS rDNA sequencing. Isolation from both symptomatic and asymptomatic seeds, as well as harvested grains, verified the seedborne nature of *S. oryzae* and several *Fusarium* spp., highlighting the potential for unnoticed pathogen dissemination. SiO_2NPs synthesized from rice husk ash characterized using Energy Dispersive Spectrometer (EDS), X-Ray Diffraction (XRD), Scanning Electron Microscope (SEM), and Particle size analysis (PSA) exhibited particle sizes ranging from 30.14 to 85.43 nm and effectively suppressed fungal growth in vitro, with chemically synthesized particles showing the highest inhibition (up to 82.22%). In vivo assays involving seed priming and foliar application, followed by artificial inoculation with *S. oryzae*, demonstrated that SiO_2NPs significantly reduced sheath rot lesion length and disease incidence by nearly 50% and induced strong upregulation of *OsPR1* defense genes, particularly *OsPR1#101*, associated with systemic acquired resistance. Although the differences across several growth, physiological, and seed quality parameters were not statistically significant, plants treated with SiO_2NPs exhibited a consistent positive trend during the seedling, vegetative, and generative stages. In conclusion, this study demonstrates that seedborne *S. oryzae* and *Fusarium* spp. pose serious risks to rice productivity, while rice husk–derived SiO_2NPs offer promising potential as an environmentally friendly strategy for sustainable sheath rot management and seed quality improvement.

Keywords: seedborne pathogens, silica nanoparticles, antifungal activity, *OsPR1* expression, sheath rot control, rice productivity

INTISARI

Penyakit busuk pelepah pada padi, yang terutama disebabkan oleh *Sarocladium oryzae* dan *Fusarium* spp., merupakan penyakit terbawa benih yang dapat menurunkan mutu benih, pertumbuhan tanaman, dan hasil panen. Penelitian ini bertujuan untuk: (i) menginvestigasi pengaruh infeksi *S. oryzae* dan *Fusarium* spp. terhadap mutu benih, pertumbuhan tanaman, dan hasil padi pada galur *cytoplasmic male sterile* (CMS 19A), hibrida (PDH 08), dan inbrida (Ciherang); (ii) mengidentifikasi patogen yang diperoleh dari benih dan jaringan tanaman menggunakan sekuensing ITS rDNA; (iii) mensintesis dan mengarakterisasi nanopartikel silika (SiO_2NPs) dari abu sekam padi melalui metode fisik, kimia, dan biologi; serta (iv) mengevaluasi aktivitas antijamur SiO_2NPs dan perannya dalam meningkatkan respons pertahanan tanaman terhadap penyakit busuk pelepah melalui ekspresi gen *OsPR1*. Benih bergejala dan tidak bergejala dari tiga tipe materi genetik padi dievaluasi untuk parameter biokimia, vigor, dan viabilitas, kemudian ditanam dalam kondisi terkontrol untuk pengamatan pertumbuhan dan hasil. Sebanyak 75 isolat jamur berhasil diperoleh dari pelepah daun, benih, dan gabah panen, dan identitas taksonominya dikonfirmasi melalui sekuensing ITS rDNA. Sifat terbawa benih dari *S. oryzae* dan beberapa *Fusarium* spp. dipastikan melalui isolasi langsung dari benih bergejala maupun tidak bergejala serta gabah panen, menegaskan potensi penyebaran patogen yang tidak terdeteksi. SiO_2NPs yang disintesis dan dikarakterisasi menggunakan Energy Dispersive Spectrometer (EDS), X-Ray Diffraction (XRD), Scanning Electron Microscope (SEM), dan Particle size analysis (PSA) memiliki ukuran partikel 30,14–85,43 nm dan mampu menghambat pertumbuhan jamur secara in vitro, dengan nanopartikel hasil sintesis kimia menunjukkan tingkat penghambatan tertinggi hingga 82,22%. Uji in vivo melalui priming benih dan aplikasi semprot, diikuti inokulasi buatan dengan *S. oryzae*, menunjukkan bahwa SiO_2NPs mampu menurunkan panjang lesi dan insidensi penyakit hampir 50% serta menginduksi peningkatan ekspresi gen *OsPR1*, terutama *OsPR1#101* yang terkait dengan mekanisme ketahanan sistemik. Meskipun perbedaan pada beberapa parameter pertumbuhan, fisiologi, dan mutu benih tidak signifikan secara statistik, perlakuan SiO_2NPs menunjukkan tren positif yang konsisten pada fase semai, vegetatif, dan generatif. Secara keseluruhan, penelitian ini menegaskan bahwa *S. oryzae* dan *Fusarium* spp. terbawa benih memiliki dampak serius terhadap produktivitas padi, sementara SiO_2NPs berbasis sekam padi berpotensi menjadi strategi ramah lingkungan yang menjanjikan untuk pengendalian hawar pelepah dan peningkatan mutu benih secara berkelanjutan.

Kata kunci: patogen tular benih, nanopartikel silika, aktivitas antijamur, ekspresi *OsPR1*, pengendalian busuk pelepah, produktivitas padi.