KAJIAN PERTAHANAN OKSIDATIF DAUN PADI (*Oryza sativa* L.) TERHADAP STRES KEKERINGAN SELAMA FASE PENGISIAN BIJI
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Produksi radikal bebas yang distimulasi oleh stres kekeringan merupakan penyebab utama kegagalan produksi tanaman pangan. Tanaman mengembangkan sistem pertahanan oksidatif secara enzimatik dan non-enzimatik untuk mendegradasi radikal bebas. Tujuan penelitian adalah untuk mengkaji sistem pertahanan oksidatif daun bendera padi yang mengalami stres kekeringan selama fase pengisian biji.

Penelitian menggunakan rancangan acak lengkap dengan tiga atau empat ulangan. Dua faktor meliputi: jenis kultivar (Situ Bagendit, kultivar tahan kering, dan Ciherang , kultivar tidak tahan kering) dan stres kekeringan (FTSW, *the fraction of transpirable soil water*: 1,0 = kontrol; 0,5 = sedang; 0,2 = ekstrem). Parameter molekuler, biokimia dan fisiologi pada daun bendera serta komponen hasil ditentukan dengan metode *semi-quantitative reverse transcription polymer chain reaction*, kolorimetri, *high perfomance liquid chromatography* dan gravimetri.

Hasil penelitian menunjukkan bahwa pola ekspresi gen *cCu-ZnSod*$_1$ dan *MnSod*$_1$, relatif sama antara kultivar tahan kering dan kultivar tidak tahan kering, sementara ekspresi *cCu-ZnSod*$_2$ meningkat pada 'Situ Bagendit' namun menurun pada kultivar tidak tahan kering. Peningkatan ekspresi gen *cApx*$_a$, *cApx*$_b$ dan *chl-sApx* terjadi pada kultivar tahan kering namun tidak terjadi pada kultivar tidak tahan kering seiring peningkatan kekeringan. Ekspresi gen *Cat*$_2$ meningkat pada kedua kultivar pada stres kekeringan ekstrem jika dibandingkan dengan tanaman tidak tercekam. Peningkatan ekspresi seiring peningkatan ditunjukkan oleh gen *Gr*$_1$ pada kultivar tahan kering dan gen *Gr*$_3$ pada kultivar tidak tahan kering. Stres kekeringan menginduksi peningkatan ekspresi gen *Sps*$_8$ pada kultivar tahan kering dan *Sps*$_1$ pada kultivar tidak tahan kering. Kandungan asam askorbat dan alfa tokoferol baik kultivar tahan kering maupun kultivar tidak tahan kering menurun seiring peningkatan stress kekeringan. Aktivitas enzim *superdioxide dismutase, ascorbate peroxidae, catalase* dan *peroxidase* meningkat pada 'Situ Bagendit' seiring peningkatan stres kekeringan. Sebaliknya aktivitas enzim *superdioxide dismutase, catalase* dan *peroxidase* pada kultivar tidak tahan kering hanya meningkat pada stres kekeringan sedang kemudian menurun pada stres kekeringan ekstrem. Aktivitas *ascorbate peroxidae* pada kultivar tidak tahan kering relatif stabil seiring peningkatan stres kekeringan. Aktivitas enzim *sucrose phosphate synthase* (SPS) dan kandungan sukrosa kultivar tahan kering dan kultivar tidak tahan kering menurun secara signifikan seiring peningkatan stres kekeringan. Khusus pada stres kekeringan ekstrem aktivitas SPS dan kandungan sukrosa pada daun bendera kultivar tahan kering lebih tinggi dibanding kultivar tidak tahan kering. Kandungan asam absisat dan indeks stabilitas membran pada daun bendera kultivar tahan kering lebih tinggi dibanding pada kultivar tidak tahan

kering selama kekeringan sedang dan ekstrim. Penurunan indeks stabiltas membran dan peningkatan *malondialdehyde* daun bendera kultivar tahan kering lebih rendah dibanding 'kultivar tidak tahan kering seiring peningkatan stres kekeringan. Kandungan klorofil a, klorofil b dan karotenoid lebih tinggi pada kultivar tahan kering dibanding kultivar tidak tahan kering pada stres kekeringan ekstrem. Stres kekeringan menyebabkan penurunan kandungan air relatif, laju fotosintesis, konduktivitas stomata dan laju transpirasi pada kedua kultivars. Peningkatan persentase biji hampa per malai dan penurunan persentase biji bernas per malai pada kultivar tahan kering lebih rendah dibanding pada perlakuan kekeringan sedang dan ekstrem. Dengan ini dapat disimpulkan bahwa sistem pertahanan oksidatif daun bendera kultivar tahan kering bekerja lebih efektif sehingga aktivitas biosintesis asimilat untuk pembentukan biji lebih tinggi dibandingkan dengan kultivar tidak tahan kering dalam merespon stres kekeringan selama fase pengisian biji.

Kata kunci: padi, kekeringan, radikal bebas, enzim, daun bendera

A STUDY OF THE RICE (*Oryza sativa* L.) LEAF OXIDATIVE DEFENCE UNDER DROUGHT STRESS DURING GRAIN FILLING PHASE

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Free radical production stimulated by drought stress is a main cause of crop yield loss. Plants develop the enzymatic and nonenzymatic oxidative defense systems for radical degradation. The research aim was to investigate the oxidative defense system of the flag leaf of rice treated to drought stress during grain filling phase.

The research used completely randomized design with two factors i.e., cultivar (Situ Bagendit, drought tolerant cultivar; and Ciherang, drought sensitive cultivar) and drought stress based on the fraction of transpirable soil water (FTSW: 1.0 = control; 0.5 = mild; 0.2 = severe). Each treatment was repeated thirdly or fourthly. The molecular, biochemical and physiological parameters of flag leaf and the yield components as well were determined by using semi-quantitative reverse transcription polymer chain reaction, colorimetric, high performance liquid chromatographic and gravimetry methods.

Expression pattern of $cCu\text{-}ZnSod_1$ and $MnSod_1$ genes in drought tolerant cultivar were similar to that in drought sensitive cultivar. The $cCu\text{-}ZnSod_2$ expression enhanced in drought tolerant cultivar but declined in drought tolerant cultivar with increase in drought stress. The enhanced expression of $cApx_a$, $cApx_b$ and *chl-sApx* genes occurred in drought tolerant cultivar but did not occur in drought tolerant cultivar following increase in drought stress. The Cat_2 expression increased in both cultivars under severe drought stress as compared to the untreated plants. The expression of the Gr_1 genes drought tolerant cultivar and of Gr_3 in drought sensitive cultivar enhanced with increase in drought stress. The Sps_1 expression decreased in drought tolerant cultivar but was stable in drought sensitive cultivar with increase in the stress. The Sps_8 expression increased in drought tolerant cultivar but declined in drought sensitive cultivar with increase in drought stress. The AAred and α-Tok content in both cultivars decreased with increase in drought stress. The activity of superdioxide dismutase, ascorbate peroxide, catalase and peroxidase enzymes in drought tolerant cultivar enhanced with increasing drought stress Whereas superdioxide dismutase, catalase and peroxidase activities in drought sensitive cultivar reduced under severe drought as compared to control. A stable activity of ascorbate peroxidase was found in drought sensitive cultivar during drought stress. The sucrose phosphate synthase (SPS) activity and sucrose content in the leaf of both cultivars declined with increasing drought stress. Especially under severe drought the leaf of drought tolerant cultivar exhibited higher SPS activity and sucrose content than the leaf of drought sensitive cultivar. Abscisic acid content in flag leaf of drought tolerant cultivar was higher than that in flag leaf of drought sensitive cultivar. The increase of index stability index and the decrease of malondialdehyde content was lower in flag leaf of drought tolerant cultivar as compared to those in flag leaf of drought sensitive cultivar under mild and severe drought. Chlorophyll a, chlorophyll b and carotenoid content in

drought tolerant cultivar leaf were higher as compared to those in drought sensitive cultivar leaf on severe drought. Drought stress caused decrease in relative water content, photosynthetic rate, stomata conductivity and transpiration rate in the flag leaf of both cultivars. The increase of the unfilled grain percentage and the decrease of the filled grain percentage in drought tolerant cultivar were lower than those in drought sensitive cultivar under mild and severe drought. The study concluded that the system of oxidative defense in flag leaf of drought tolerant cultivar acted more effectively for coping with the destructive activity of free radical during drought stress than that of drought sensitive cultivar did.

Key words: rice, drought, free radical, enzyme, flag leaf