ABSTRACT

Manganese (Mn) toxicity is one of the limiting factors for tomato plants grown in acidic soils. Genetic control of the tolerance mechanism has yet to be understood due to limited research on this issue. Furthermore, physiological and growth responses, as well as tolerance mechanisms modulated by the genes SlMTP8 and SlMTP10, that determine the tolerance among tomato genotypes to Mn toxicity is unclear. This study aimed to obtain tomato genotypes tolerant to Mn stress and information on the physiological response, inheritance patterns, and gene expression of these two genes on distinctive tomato genotypes grown under Mn stress. The experiment was conducted in three stages. The first stage was screening four tomato genotypes, Opal, Mirah, Ratna, and Mutiara, in four treatments of Mn concentrations, namely 0.3 ppm (control), 50 ppm, 100 ppm, and 200 ppm. The screening was carried out using hydroponic culture. The second stage consisted of characterizing the F_2 population of crosses between Mirah (tolerant) and Mutiara (sensitive) as a result of screening. The characterization was based on growth, yield, physiological response, genetic analysis, and molecular expression of genes SlMTP8 and SlMTP10. Planting in the second stage was carried out in polybags using Ultisols soil with high Mn. Furthermore, the third phase of the study was conducted to determine the expression of the SlMTP8 and SlMTP10 genes in the Mn-stressed for both Mirah and Mutiara. The 50 ppm Mn treatment and hydroponic culture were applied in the third stage of the study. The results showed a difference in tolerance to Mn toxicity between Mirah, Mutiara, Opal, and Ratna with tolerance levels of Mirah > Opal > Ratna > Mutiara. The difference in physiological response between Mirah (Mn tolerant) and Mutiara (Mn sensitive) was mainly indicated by the chlorophyll fluorescence characters and chlorophyll content. Chlorophyll content and fruit set are controlled by many genes (quantitative traits). Meanwhile, chlorophyll fluorescence, flowering time, harvesting time, total fruit weight per plant, number of fruits per plant, and weight per fruit are characters controlled by a few genes (qualitative traits). Selection based on chlorophyll fluorescence, flowering age, harvesting age, total fruit weight per plant, number of fruits per plant, and weight per fruit can be conducted in early generations. In contrast, selection based on chlorophyll content and fruit set characters must be done in later generations. The expression of SlMTP8 and SlMTP10 could differentiate between tomato genotypes tolerant and sensitive to Mn stress. The expression of both genes SlMTP8 and SlMTP10 increased (up-regulated) in Mirah when exposed to Mn stress (50 ppm). Otherwise, the SlMTP8 was only expressed under Mn stress conditions, and the expression of the SlMTP10 decreased (down-regulated) in Mutiara when exposed to Mn stress. This information is useful in developing Mn-tolerant tomato genotypes in acidic soils, especially in Indonesia.

Keywords: *chlorophyll fluorescence; manganese toxicity; metal tolerance protein; tolerance index; tomato*

ABSTRAK

Toksisitas mangan (Mn) merupakan salah satu faktor pembatas pertumbuhan tanaman tomat pada tanah masam. Kendali genetik pada mekanisme toleransi masih sedikit diketahui karena terbatasnya penelitian terkait hal tersebut. Selanjutnya, respons fisiologis dan pertumbuhan, serta mekanisme toleransi yang dimediasi oleh gen *Sl*MTP8 dan *Sl*MTP10, yang menentukan toleransi antar genotipe tomat terhadap toksisitas Mn masih belum jelas. Penelitian ini bertujuan untuk mendapatkan genotip tomat yang toleran terhadap cekaman Mn, respons fisiologis, pola pewarisan dan ekspresi dari kedua gen tersebut pada genotip tomat khas yang tumbuh di bawah cekaman Mn. Percobaan dilakukan dalam tiga tahap. Tahap pertama adalah skrining empat genotip tomat yaitu Opal, Mirah, Ratna dan Mutiara dengan empat perlakuan konsentrasi Mn yaitu 0,3 ppm (kontrol), 50 ppm, 100 ppm dan 200 ppm. Skrining dilakukan dengan menggunakan kultur hidroponik. Tahap kedua berupa kegiatan karakterisasi populasi F_2 persilangan genotip Mirah (toleran) dan genotip Mutiara (peka) hasil skrining. Karakterisasi dilakukan berdasarkan pertumbuhan, daya hasil, respons fisiologis, analisis genetik serta pendekatan secara molekuler dengan gen *Sl*MTP8 dan *Sl*MTP10. Penanaman pada tahap kedua dilakukan dalam *polybag* dengan tanah Ultisol yang mengandung Mn tinggi. Selanjutnya, penelitian tahap ketiga dilakukan untuk mengetahui ekspresi gen *Sl*MTP8 dan *Sl*MTP10 pada genotip Mirah dan Mutiara yang tercekam Mn. Perlakuan Mn 50 ppm dan kultur hidroponik digunakan pada penelitian tahap ketiga. Hasil penelitian menunjukkan adanya perbedaan toleransi terhadap toksisitas Mn antara genotip Mirah, Mutiara, Opal dan Ratna dengan tingkatan toleransi Mirah > Opal > Ratna > Mutiara. Perbedaan respons fisiologis antara genotip Mirah (toleran Mn) dan genotip Mutiara (peka Mn) terutama ditunjukkan oleh karakter floresensi klorofil dan kadar klorofil. Kadar klorofil dan *fruit set* merupakan karakter-karakter yang dikendalikan oleh banyak gen (karakter kuantitatif). Sementara itu, floresensi klorofil, umur berbunga, umur panen, total berat buah per tanaman, jumlah buah per tanaman, dan berat per buah merupakan karakter-karakter yang dikendalikan oleh sedikit gen (karakter kualitatif). Seleksi berdasarkan floresensi klorofil, umur berbunga, umur panen, total berat buah per tanaman, jumlah buah per tanaman, dan berat per buah dapat dilakukan pada generasi awal, sedangkan seleksi berdasarkan kadar klorofil dan *fruit set* harus dilakukan pada generasi lanjut. Ekspresi gen *Sl*MTP8 dan *Sl*MTP10 dapat membedakan antara genotip tomat yang toleran dan peka terhadap cekaman Mn. Ekspresi gen *Sl*MTP8 dan *Sl*MTP10 pada Mirah meningkat (*up-regulated*) saat tercekam Mn (50 ppm), sedangkan pada Mutiara, *Sl*MTP8 terekspresi hanya pada kondisi stres Mn, dan ekspresi *Sl*MTP10 menurun (*down-regulated*) saat tercekam Mn. Informasi ini diharapkan berkontribusi untuk perbaikan sifat genetik dan perakitan genotip tomat toleran Mn di tanah masam khususnya di Indonesia.

Kata kunci: floresensi klorofil; toksisitas mangan; *metal tolerance protein*; indeks toleransi, tomat.