ABSTRAK

RESPON EKOFISIOLOGIS DAN PERTAHANAN ANTIOKSIDATIF PINAK PISANG (*Musa* spp.) TERHADAP CEKAMAN KROMIUM (Cr) SECARA *IN-VITRO*

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Industri penyamakan kulit merupakan industri yang menghasilkan limbah berbahaya, karena mengandung logam berat Kromium (Cr). Limbah ini pada umumnya dibuang langsung ke sungai tanpa melalui pengolahan terlebih dahulu, sehingga menjadi pencemar air dan tanah di sekitarnya. Berdasarkan literatur diketahui bahwa dalam tumbuhan, Cr dapat menyebabkan terjadinya kerusakan DNA, protein, pigmen-pigmen fotosintetik, ultrastruktur kloroplas dan membran sel, sehingga dapat menghambat perkecambahan, menghambat proses fotosintesis, proses respirasi, menghambat pembelahan sel dan akhirnya menghambat pertumbuhan dan menurunkan hasil panen. Oleh karena itu tumbuhan yang hidup di tanah tercemar Cr harus mempunyai mekanisme toleransi agar dapat tetap hidup dan produktif. Salah satu jenis tumbuhan yang ditanam penduduk di tanah tercemar Cr (daerah Sukaregang Garut, sentra industri penyamakan kulit) adalah pisang kultivar Ambon Lumut (*Musa acuminata* Colla) dan pisang kultivar Nangka (*M. paradisiaca* L.), sehingga dilakukan penelitian yang bertujuan untuk mengevaluasi: 1) Respon ekofisiologis pinak pisang terhadap cekaman Cr dengan menganalisis parameter pertumbuhan dan kandungan klorofilnya, 2) Kemampuan pinak pisang mengakumulasi Cr dengan menganalisis kandungan Cr dalam jaringan tanaman, 3) Pertahanan antioksidatif pinak pisang terhadap cekaman Cr dengan menganalisis kandungan prolin, aktivitas enzim antioksidan (katalase = CAT dan askorbat peroksidase = APX) serta ekspresi gen *CAT* dan gen *APX*. Pengamatan awal dilakukan di sekitar IPAL (Instalasi Pengolah Air Limbah) Sukaregang Garut dengan mengukur kandungan Cr pada tanah dan tanaman pisang yang tumbuh di tanah ini. Pengujian selanjutnya dilakukan secara *in-vitro* pada pinak pisang kultivar Ambon Lumut dan kultivar Nangka yang berasal dari tanah tercemar Cr (*Putative* Toleran = PT) dan dari tanah tidak tercemar (Non *Putative* Toleran = NPT) yang diberi perlakuan Cr masing-masing 0 ppm, 50 ppm, 100 ppm, 200 ppm dan 400 ppm. Hasil pengamatan awal menunjukkan bahwa tanah di sekitar IPAL Sukaregang mengandung Cr 344 ppm, sedangkan akumulasi Cr tertinggi terdapat pada akar pisang Ambon Lumut dan pisang Nangka. Hasil penelitian selanjutnya menunjukkan bahwa laju pertumbuhan relatif, tinggi pinak dan jumlah daun pinak pisang semakin berkurang seiring dengan bertambahnya konsentrasi Cr pada medium. Laju pertumbuhan relatif

tertinggi ditunjukkan oleh pinak pisang Ambon Lumut PT (pada perlakuan Cr 50 ppm), sedangkan tinggi pinak tertinggi dan jumlah daun terbanyak pada pinak pisang Nangka PT (pada perlakuan 50 ppm). Indeks Toleransi tertinggi terdapat pada pinak pisang Ambon Lumut PT (pada perlakuan 100 ppm). Kandungan klorofil tertinggi terdapat pada pinak pisang Nangka PT (pada perlakuan 50 ppm). Kandungan Cr pada pinak pisang semakin tinggi dengan bertambahnya konsentrasi Cr pada medium. Kandungan Cr terbesar di akar dan di pucuk terdapat pada pinak pisang Nangka PT (pada perlakuan 400 ppm). Indeks Transportasi tertinggi terdapat pada pinak pisang Ambon Lumut PT (pada perlakuan 50 ppm). Faktor Biokonsentrasi tertinggi pada pinak pisang Nangka PT (pada konsentrasi 400 ppm). Kandungan prolin pada akar dan pucuk menunjukkan tidak ada perbedaan, baik di antara kultivar maupun di antara konsentrasi yang berbeda, tetapi yang tertinggi terdapat pada daun pinak pisang Nangka PT (pada perlakuan 400 ppm). Aktivitas enzim katalase (CAT) dan askorbat peroksidase (APX) pada semua kultivar menunjukkan ada perbedaan, sedangkan di antara konsentrasi Cr yang berbeda, tidak ada perbedaan. Aktivitas enzim CAT tertinggi di akar terdapat pada pinak pisang Nangka PT (pada perlakuan 200 ppm), sedangkan di pucuk aktivitas enzim CAT tertinggi terdapat pada pinak pisang Ambon Lumut NPT (pada perlakuan 50 ppm). Aktivitas enzim APX tertinggi di akar terdapat pada pinak pisang Nangka NPT (pada perlakuan 400 ppm), sedangkan di pucuk aktivitas enzim APX tertinggi terdapat pada pinak pisang Nangka PT (pada perlakuan 50 ppm). Pada pinak pisang kultivar PT, level ekspresi gen *CAT* dan gen *APX* lebih tinggi dibanding kontrol. Pada tanaman pisang NPT, level ekspresi gen *CAT* dan gen *APX* lebih rendah dibandingkan dengan tanaman pisang PT. Berdasarkan pengamatan awal dapat diketahui bahwa tanah sekitar IPAL Sukaregang Kab. Garut termasuk tanah tercemar Cr dan tanaman pisang di sekitar IPAL mengakumulasi Cr, terutama di bagian akar. Berdasarkan penelitian selanjutnya dapat disimpulkan: (1) Respon ekofisiologis pinak pisang (*Musa* spp.) terhadap cekaman Cr ditunjukkan dengan laju pertumbuhan relatif, tinggi tanaman, jumlah daun dan kandungan klorofil yang semakin menurun seiring dengan bertambahnya konsentrasi Cr pada medium tanam; Respon ekofisiologis pinak pisang kultivar PT terhadap cekaman Cr ditunjukkan dengan laju pertumbuhan relatif, tinggi tanaman, jumlah daun dan kandungan klorofil yang lebih tinggi dibanding pinak pisang NPT, (2) Pinak pisang Ambon Lumut dan pisang Nangka mengakumulasi Cr dengan jumlah yang tinggi, (3) Pertahanan antioksidatif pinak pisang (*Musa* spp.) terhadap cekaman Cr ditunjukkan dengan kandungan prolin pada daun, aktivitas enzim CAT dan APX serta ekspresi gen *CAT* dan gen *APX* yang cenderung semakin tinggi dengan bertambahnya konsentrasi Cr pada medium tanam; Pertahanan antioksidatif pinak pisang kultivar PT terhadap cekaman Cr ditunjukkan dengan kandungan prolin dan level ekspresi gen *CAT* dan *APX* yang cenderung lebih tinggi, sedangkan aktivitas enzim CAT pada pucuk dan APX pada akar yang lebih rendah dibanding pinak pisang NPT.

Kata Kunci: Respon Ekofisiologis, Pertahanan Antioksidatif, *Musa acuminata* Colla, *Musa paradisiaca* L., Cekaman Kromium.

ABSTRACT

ECOPHYSIOLOGICAL RESPONSES AND ANTIOXIDATIVE DEFENSE OF BANANA PLANTLETS (*Musa* spp.) TO CHROMIUM (Cr) STRESS IN IN-VITRO CONDITION

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Leather tanning industry generates hazardous waste which contains heavy metals chromium (Cr). These wastes are generally dumped directly into the river without any waste treatment in advance. Consequently, it can pollute surrounding water and soil. Cr is known to cause the damage to DNA, proteins, photosynthetic pigments, ultrastructure of chloroplasts and cell membranes. It also inhibits germination, the process of photosynthesis, respiration, cell division and ultimately inhibits the growth and consequently lower plant yields. Therefore, plants that grow in Cr contaminated soil, should have be able to tolerate Cr contamination. Banana cultivars Ambon Lumut (*Musa acuminata* Colla) and banana cultivars Nangka (*M. paradisiaca* L.) have been planted by local people in Cr-polluted river side soil. The research is aimed to understand: 1) the ecophysiological responses of banana plantlets to Cr stress by analyzing growth parameters and chlorophyll content, 2) the ability of banana plantlets as Cr accumulator by analyzing the content of Cr in plant tissue, 3) antioxidative defense mechanism of banana plantlets to Cr stress by analyzing proline content, activity of antioxidant enzymes (catalase = CAT and ascorbate peroxidase = APX) and also expression of *CAT* and *APX* genes. Observations were done at around IPAL (Waste Water Treatment Plant) Sukaregang Garut by measuring the content of Cr in soil and banana plants that grow in this soil. The next experiment was conducted *in-vitro* using plantlets of banana cultivars Ambon Lumut and cultivars Nangka from Cr contaminated-soil (Putative Tolerant = PT) and planlets from non-contaminated soil (Non Putative Tolerant = PNT) with 0 ppm, 50 ppm, 100 ppm, 200 ppm and 400 ppm treatments. The results showed that the relative growth rate, the height and the number of banana leaves decreased in line with the increase of Cr concentrations in the medium. The highest relative growth rate was in Ambon Lumut PT banana plantlets (50 ppm Cr treatment), the height and the number of leaves in Nangka PT banana plantlets (50 ppm Cr treatment). The highest Tolerance Index was in Ambon Lumut PT banana plantlets (100 ppm Cr treatment). The highest chlorophyll content was found on Nangka PT banana plantlets (50 ppm Cr treatment). The content of Cr in the banana plantlets was higher with the increase of the concentrations of Cr in the medium. The highest Cr content in the roots of banana plantlets was on Nangka NPT (400 ppm Cr treatment) as well as in the shoots was on Nangka PT banana plantlets (400 ppm

Cr treatment). The highest Transportation Index was found in Ambon Lumut PT banana plantlets (50 ppm Cr treatment). The highest Bioconcentration Factor was found in Nangka PT banana plantlets (400 ppm treatment). The content of proline in roots and shoots showed no differences, for both cultivars and different concentration. However, the largest proline content found in the leaves of Nangka PT banana plantlets (400 ppm Cr treatment). The enzyme activity of catalase (CAT) and ascorbate peroxidase (APX) in all cultivars showed the differences; whereas, among the different concentrations of Cr there was no difference. Highest CAT enzyme activity in the roots of banana plantlets was found in Nangka PT (200 ppm Cr treatment); while, at the shoots found in Ambon Lumut NPT banana plantlets (50 ppm Cr treatment). Highest APX enzyme activity was found in roots of Nangka NPT banana plantlets (400 ppm Cr treatment); while, at the shoots was on Nangka PT banana plantlets (50 ppm Cr treatment). In PT banana plantlets, the level of *CAT* gene expression and *APX* gene was higher than the control. In NPT banana plantlets, the level of *CAT* gene expression and *APX* gene were lower. Based on preliminary observations can be known that the soil around IPAL Sukaregang was categorized into Cr contaminated soil and banana plants around IPAL accumulated Cr, especially in the roots. Based on further research it can be concluded that: (1) The ecophysiological responses of the banana plantlets (*Musa* spp.) to Cr stress was indicated by the reduction relative growth rate, the height, the number of leaves and chlorophyll content with increase concentrations of Cr in the medium; The ecophysiological responses of the PT banana plantlets to Cr stress was indicated by the growth rate, the height, the number of leaves and chlorophyll content was higher than the NPT banana plantlets, (2) Banana plantlets cultivars Ambon Lumut and cultivars Nangka were categorized into a Very High Cr Hyperaccumulator, (3) Antioxidative defense mechanism of banana plantlets (*Musa* spp.) to Cr stress was indicated by proline content in the leaves, the CAT and APX enzymes activity and *CAT* and *APX* genes expression that tended to be higher by the increase of Cr concentrations in the medium; Antioxidative defense mechanism of PT banana plantlets to Cr stress was indicated by the content of proline and level of *CAT* and *APX* genes expression that tended to be higher, while the CAT enzyme activity at the shoots and APX enzyme activity in the roots was lower than the NPT banana plantlets.

Keywords: Ecophysiological Responses, Antioxidative Defense, *Musa acuminata* Colla, *Musa paradisiaca* L., Chromium Stress.