UNIVERSITAS
GADJAH MADA
Identification of Physiological Traits and QTLs Associated with Drought Resistance in Rubber (Hevea brasiliensis Muell. Arg.) using PB 260 x SP 217 Population and Several Control Clones
ANDI NUR CAHYO, Dr. Rudi Hari Murti, S.P., M.P.; Eka Tarwaca Susila Putra, S.P., M.P., Ph.D.; Dr. Pascal Montoro
Universitas Gadjah Mada, 2022 | Diunduh dari http://etd.repository.ugm.ac.id/

REFERENCES

Ahmad, P., Jaleel, C.A., Azooz, M.M., Nabi, G., 2009. Generation of ROS and Non-Enzymatic Antioxidants During Abiotic Stress in Plants. Bot. Res. Int. 2, 11–20.

Ahmad, P., Sarwat, M., Sharma, S., 2008. Reactive oxygen species, antioxidants and signaling in plants. J. Plant Biol. 51, 167–173. https://doi.org/10.1007/BF03030694

Akram, N.A., Shafiq, F., Ashraf, M., 2017. Ascorbic Acid-A Potential Oxidant Scavenger and Its Role in Plant Development and Abiotic Stress Tolerance. Front. Plant Sci. 8, 1–17.

Alexieva, V., Sergiev, I., Mapelli, S., Karanov, E., 2001. The effect of drought and ultraviolet radiation on growth and stress markers in pea and wheat. Plant Cell Environ. 24, 1337–1344. https://doi.org/10.1046/j.1365-3040.2001.00778.x

Alscher, R.G., Erturk, N., Heath, L.S., 2002. Role of superoxide dismutases (SODs) in controlling oxidative stress in plants. J. Exp. Bot. 53, 1331–1341.

An, F., Kong, L., Gong, L., Wang, Z., Lin, W., 2011. Involvement of rootstocks and their hydraulic conductance in the drought resistance of grafted rubber trees. Afr. J. Biotechnol. 10, 10393–10404. https://doi.org/10.5897/AJB11.354

An, Z., Zhao, Y., Zhang, X., Huang, X., Hu, Y., Cheng, H., Li, X., Huang, H., 2019. A high-density genetic map and QTL mapping on growth and latex yield-related traits in *Hevea brasiliensis* Müll.Arg. Ind. Crops Prod. 132, 440–448. https://doi.org/10.1016/j.indcrop.2019.03.002

Ardika, R., Cahyo, A.N., Wijaya, T., 2011. Wintering and Yield Dynamics on Various Rubber Clones and Their Relationship to Soil Water Content. Indones. J. Nat. Rubber Res. 29, 102–109.

Asada, K., 2006. Production and Scavenging of Reactive Oxygen Species in Chloroplasts and Their Functions. PLANT Physiol. 141, 391–396. https://doi.org/10.1104/pp.106.082040

Ayutthaya, S.I.N., 2010. Change of whole-tree transpiration of mature *Hevea brasiliensis* under soil and atmospheric droughts: analyze in intermittent and seasonal droughts under the framework of the hydraulic limitation hypothesis (Doctoral Thesis). Universite Blaise Pascal, France.

Azhar, A., Sathornkich, J., Rattanawong, R., Kasemsap, P., 2013. Responses of Chlorophyll Fluorescence, Stomatal Conductance, and Net Photosynthesis Rates of Four Rubber *(Hevea brasiliensis)* Genotypes to Drought. Adv. Mater. Res. 844, 11–14. https://doi.org/10.4028/www.scientific.net/AMR.844.11

Azis, M., Dermoredjo, S.K., Sayaka, B., Purwaningrat, L., 2021. Economic perspective of indonesian rubber on agroforestry development. E3S Web Conf. 305, 02007. https://doi.org/10.1051/e3sconf/202130502007

UNIVERSITAS
GADJAH MADA
Identification of Physiological Traits and QTLs Associated with Drought Resistance in Rubber (Hevea brasiliensis Muell. Arg.) using PB 260 x SP 217 Population and Several Control Clones
ANDI NUR CAHYO, Dr. Rudi Hari Murti, S.P., M.P.; Eka Tarwaca Susila Putra, S.P., M.P., Ph.D.; Dr. Pascal Montoro
Universitas Gadjah Mada, 2022 | Diunduh dari http://etd.repository.ugm.ac.id/

Baker, N.R., Rosenqvist, E., 2004. Applications of chlorophyll fluorescence can improve crop production strategies: an examination of future possibilities. J. Exp. Bot. 55, 1607–1621. https://doi.org/10.1093/jxb/erh196

Balsalobre, T.W.A., da Silva Pereira, G., Margarido, G.R.A., Gazaffi, R., Barreto, F.Z., Anoni, C.O., Cardoso-Silva, C.B., Costa, E.A., Mancini, M.C., Hoffmann, H.P., de Souza, A.P., Garcia, A.A.F., Carneiro, M.S., 2017. GBS-based single dosage markers for linkage and QTL mapping allow gene mining for yield-related traits in sugarcane. BMC Genomics 18. https://doi.org/10.1186/s12864-016-3383-x

Barry, R.G., Chorley, R.J., 1976. Atmosphere, Weather and Climate, 2nd ed. Routledge, Methuen, London.

Bates, L.S., Waldren, R.P., Teare, I.D., 1973. Rapid determination of free proline for water stress studies. Plant Soil 39, 205–207.

Botstein, D., White, R.L., Skolnick, M., Davis, R.W., 1980. Construction of a Genetic Linkage Map in Man Using Restriction Fragment Length Polymorphisms. Am. Soc. Hum. Genet. 32, 314–331.

Boureima, S., Oukarroum, A., Diouf, M., Cisse, N., Van Damme, P., 2012. Screening for drought tolerance in mutant germplasm of sesame (*Sesamum indicum*) probing by chlorophyll a fluorescence. Environ. Exp. Bot. 81, 37–43. https://doi.org/10.1016/j.envexpbot.2012.02.015

Bréda, N., Huc, R., Granier, A., Dreyer, E., 2006. Temperate forest trees and stands under severe drought: a review of ecophysiological responses, adaptation processes and long-term consequences. Ann. For. Sci. 63, 625–644. https://doi.org/10.1051/forest:2006042

Cahyo, A.N., Murti, R.H., Putra, E.T.S., Nuringtyas, T.R., Fabre, D., Montoro, P., 2021. Assessment of factual measurement times for chlorophyll-*a* fluorescence in rubber (*Hevea brasiliensis*) clones. Biodiversitas J. Biol. Divers. 22, 3470–3477. https://doi.org/10.13057/biodiv/d220656

Cahyo, A.N., Murti, R.H., Putra, E.T.S., Nuringtyas, T.R., Fabre, D., Montoro, P., 2020. SPAD-502 and atLEAF CHL PLUS values provide good estimation of the chlorophyll content for *Hevea brasiliensis* Müll. Arg. leaves. Menara Perkeb. 88, 1–8. http://dx.doi.org/10.22302/iribb.jur.mp.v88i1.369

Çelik, Ö., Atak, Ç., 2012. The effect of salt stress on antioxidative enzymes and proline content of two Turkish tobacco varieties. Turk. J. Biol. 36, 339-356.

Ceulemans, R., Gabriels, R., Impens, I., 1984. Comparative study of photosynthesis in several *Hevea brasiliensis* clones and Hevea species under tropical field conditions. Trop. Agric. Trinidad 61, 273–275.

UNIVERSITAS
GADJAH MADA
Identification of Physiological Traits and QTLs Associated with Drought Resistance in Rubber (Hevea brasiliensis Muell. Arg.) using PB 260 x SP 217 Population and Several Control Clones
ANDI NUR CAHYO, Dr. Rudi Hari Murti, S.P., M.P.; Eka Tarwaca Susila Putra, S.P., M.P., Ph.D.; Dr. Pascal Montoro
Universitas Gadjah Mada, 2022 | Diunduh dari http://etd.repository.ugm.ac.id/

Chandra, K., Pandey, A., 2017. QTL Mapping in Crop Improvement: A Basic Concept. Int. J. Curr. Microbiol. Appl. Sci. 6, 835–842. https://doi.org/10.20546/ijcmas.2017.612.089

Chandrashekar, T.R., Nazeer, M.A., Marattukalam, J.G., Prakash, G.P., Annamalainathan, K., Thomas, J., 1998. An analysis of growth and drought tolerance in rubber during the immature phase in a dry subhumid climate. Exp. Agric. 34, 287–300. https://doi.org/10.1017/S0014479798343045

Chaves, M.M., 1991. Effects of Water Deficits on Carbon Assimilation. J. Exp. Bot. 42, 1–16. https://doi.org/10.1093/jxb/42.1.1

Chaves, M.M., Flexas, J., Pinheiro, C., 2009. Photosynthesis under drought and salt stress: regulation mechanisms from whole plant to cell. Ann. Bot. 103, 551–560. https://doi.org/10.1093/aob/mcn125

Chehrit-Hacid, F., Derridj, A., Moulti-Mati, F., Mati, A., 2015. Drought stress effect on some biochemical and physiological parameters; accumulation of total polyphenols and flavonoids in leaves of two provenance seedling Pistacia lentiscus. IMPACT Int. J. Res. Appl. Nat. Soc. Sci. 3, 127–138.

Chen, M., Zhu, X., Zhang, Y., Du, Z., Chen, X., Kong, X., Sun, W., Chen, C., 2020. Drought stress modify cuticle of tender tea leaf and mature leaf for transpiration barrier enhancement through common and distinct modes. Sci. Rep. 10, 6696. https://doi.org/10.1038/s41598-020-63683-4

Christopher, M., Chenu, K., Jennings, R., Fletcher, S., Butler, D., Borrell, A., Christopher, J., 2018. QTL for stay-green traits in wheat in well-watered and water-limited environments. Field Crops Res. 217, 32–44. https://doi.org/10.1016/j.fcr.2017.11.003

Churchill, G.A., Doerge, R.W., 1994. Empirical Threshold Values for Quantitative Trait Mapping. Genetics 138, 963–971.

Çiçek, N., Arslan, Ö., 2015. Are The Photosynthetic Performance Indexes and The Drought Factor Index Satisfactory Selection Criterion for Stress? Fresenius Environ. Bull. 24, 4190–4198.

Clément-Demange, A., Prapan, K., Ratanawong, R., Teerawatanasuk, K., 2006. Molecular genetic markers and rubber breeding in Thailand 2 – Field study of the family RRIM600 x PB217 for QTL identification, in: Franco-Thai Project 2005-2008: “Towards the Improvement of Rubber Tree Productivity.” Bangkok, Thailand, pp. 1–21.

Conson, A.R.O., Taniguti, C.H., Amadeu, R.R., Andreotti, I.A.A., de Souza, L.M., dos Santos, L.H.B., Rosa, J.R.B.F., Mantello, C.C., da Silva, C.C., José Scaloppi Junior, E., Ribeiro, R.V., Le Guen, V., Garcia, A.A.F., Gonçalves, P. de S., de Souza, A.P., 2018. High-Resolution Genetic Map and QTL Analysis of Growth-Related Traits of *Hevea brasiliensis* Cultivated Under Suboptimal Temperature and Humidity Conditions. Front. Plant Sci. 9. https://doi.org/10.3389/fpls.2018.01255

UNIVERSITAS
GADJAH MADA
Identification of Physiological Traits and QTLs Associated with Drought Resistance in Rubber (Hevea brasiliensis Muell. Arg.) using PB 260 x SP 217 Population and Several Control Clones
ANDI NUR CAHYO, Dr. Rudi Hari Murti, S.P., M.P.; Eka Tarwaca Susila Putra, S.P., M.P., Ph.D.; Dr. Pascal Montoro
Universitas Gadjah Mada, 2022 | Diunduh dari http://etd.repository.ugm.ac.id/

Daslin, A., 2013. Produktivitas Klon Karet pada Berbagai Kondisi Lingkungan di Perkebunan. Agrium 18, 1–6.

de Raissac, M., Perez, R., Fabre, D., 2017. New Challenges in Oil Palm Phenotyping in Relation to Climate, in: Soh, A.C., Mayes, S., Roberts, J. (Eds.), Oil Palm Breeding, Genetics and Genomics. CRC Press, Taylor & Francis Group, LLC, Boca Raton, p. 446.

de Souza, A.T., Streck, N.A., Heldwein, A.B., Bisognin, D.A., Winck, J.E.M., da Rocha, T.S.M., Zanon, A.J., 2014. Transpiration and leaf growth of potato clones in response to soil water defi cit. Sci. Agric. 71, 96–104.

Dijkman, M.J., 1951. Hevea – Thirty Years of Research in The Far East. University of Miami Press, Florida.

Dionisio-Sese, M.L., Tobita, S., 1998. Antioxidant responses of rice seedlings to salinity stress. Plant Sci. 135, 1–9. https://doi.org/10.1016/S0168-9452(98)00025-9

Directorate General of Estate Crops, 2020. Statistical of National Leading Estate Crops Commodity 2019-2021. Secretariate of Directorate General of Estate Crops, Directorate General of Estate Crop, Ministry of Agriculture, Jakarta.

Directorate General of Estate Crops, 2017. Collection of Description of Superior Plant Material Varieties of Plantation Crops. Directorate General of Estate Crops, Ministry of Agriculture, Jakarta.

Directorate General of Estate Crops, 2016. Tree Crop Estate Statistics of Indonesia 2015-2017.

Directorate of Food Crops, Horticulture, and Estate Crops Statistics, 2021. Indonesian Rubber Statistics 2020. BPS–Statistics Indonesia, Jakarta.

Fabre, D., 2019. Personal Communication.

Falqueto, A.R., da Silva Júnior, R.A., Gomes, M.T.G., Martins, J.P.R., Silva, D.M., Partelli, F.L., 2017. Effects of drought stress on chlorophyll a fluorescence in two rubber tree clones. Sci. Hortic. 224, 238–243. https://doi.org/10.1016/j.scienta.2017.06.019

Fang, Y., Xiong, L., 2015. General mechanisms of drought response and their application in drought resistance improvement in plants. Cell. Mol. Life Sci. 72, 673–689. https://doi.org/10.1007/s00018-014-1767-0

Feng, S.P., Li, W.G., Huang, H.S., Wang, J.Y., Wu, Y.T., 2009. Development, characterization and cross-species/genera transferability of EST-SSR markers for rubber tree (Hevea brasiliensis). Mol. Breed. 23, 85–97. https://doi.org/10.1007/s11032-008-9216-0

Fikret, Y., Manar, T., Şebnem, E., Şebnem, K., Özlem, U., 2013. SOD, CAT, GR and APX Enzyme Activities in Callus Tissues of Susceptible and Tolerant Eggplant Varieties under Salt Stress. Res. J. Biotechnol. 8, 45–51.

UNIVERSITAS
GADJAH MADA
Identification of Physiological Traits and QTLs Associated with Drought Resistance in Rubber (Hevea brasiliensis Muell. Arg.) using PB 260 x SP 217 Population and Several Control Clones
ANDI NUR CAHYO, Dr. Rudi Hari Murti, S.P., M.P.; Eka Tarwaca Susila Putra, S.P., M.P., Ph.D.; Dr. Pascal Montoro
Universitas Gadjah Mada, 2022 | Diunduh dari http://etd.repository.ugm.ac.id/

Foyer, C.H., Noctor, G., 2005. Oxidant and antioxidant signalling in plants: a re-evaluation of the concept of oxidative stress in a physiological context. Plant Cell Environ. 28, 1056–1071. https://doi.org/10.1111/j.1365-3040.2005.01327.x

Foyer, C.H., Noctor, G., 2003. Redox sensing and signalling associated with reactive oxygen in chloroplasts, peroxisomes and mitochondria. Physiol. Plant. 119, 355–364. https://doi.org/10.1034/j.1399-3054.2003.00223.x

Foyer, C.H., Noctor, G., 2000. Tansley Review No. 112: Oxygen processing in photosynthesis: regulation and signalling. New Phytol. 146, 359–388. https://doi.org/10.1046/j.1469-8137.2000.00667.x

FT GREEN LLC, 2019. atLEAF CHL PLUS Chlorophyll Meter User Manual 0131-50 Ver 1.1.

Geldermann, H., 1976. Investigations on inheritance of quantitative characters in animals by gene markers II. Expected effects. Theor. Appl. Genet. 47, 1–4. https://doi.org/10.1007/BF00277397

George, P.J., Panikkar, A.O.N., 2000. Rubber Yielding Plants, in: George, P.J., Jacob, C.K. (Eds.), Natural Rubber : Agromanagement and Crop Processing. Rubber Research Institute of India, Kerala.

Ghimire, K.H., Quiatchon, L.A., Vikram, P., Swamy, B.P.M., Dixit, S., Ahmed, H., Hernandez, J.E., Borromeo, T.H., Kumar, A., 2012. Identification and mapping of a QTL (qDTY1.1) with a consistent effect on grain yield under drought. Field Crops Res. 131, 88–96. https://doi.org/10.1016/j.fcr.2012.02.028

Giorio, P., 2011. Black leaf-clips increased minimum fluorescence emission in clipped leaves exposed to high solar radiation during dark adaptation. Photosynthetica 49, 371–379. https://doi.org/10.1007/s11099-011-0040-0

Giorio, P., Nuzzo, V., Guida, G., Albrizio, R., 2012. Black leaf-clips of a commercial fluorometer increased leaf temperature during dark adaptation under high solar radiation. Photosynthetica 50, 467–471. https://doi.org/10.1007/s11099-012-0042-6

Govindje, e, 1995. Sixty-Three Years Since Kautsky: Chlorophyll a Fluorescence. Funct. Plant Biol. 22, 131. https://doi.org/10.1071/PP9950131

Gregory, P.J., 1984. Water availability and crop growth in arid regions. Outlook Agric. 13, 208–215.

Guo, H., Sun, Y., Peng, X., Wang, Q., Harris, M., Ge, F., 2016. Up-regulation of abscisic acid signaling pathway facilitates aphid xylem absorption and osmoregulation under drought stress. J. Exp. Bot. 67, 681–693. https://doi.org/10.1093/jxb/erv481

Hallé, F., Martin, R., 1968. Etude de la croissance rythmique chez l'Hévéa (*Hevea brasiliensis* Mull. Arg.). Adansonia 2, 475–503.

UNIVERSITAS
GADJAH MADA
Identification of Physiological Traits and QTLs Associated with Drought Resistance in Rubber (Hevea brasiliensis Muell. Arg.) using PB 260 x SP 217 Population and Several Control Clones
ANDI NUR CAHYO, Dr. Rudi Hari Murti, S.P., M.P.; Eka Tarwaca Susila Putra, S.P., M.P., Ph.D.; Dr. Pascal Montoro
Universitas Gadjah Mada, 2022 | Diunduh dari http://etd.repository.ugm.ac.id/

Halliwell, B., 2006. Reactive Species and Antioxidants. Redox Biology Is a Fundamental Theme of Aerobic Life. PLANT Physiol. 141, 312–322. https://doi.org/10.1104/pp.106.077073

Hamim, H., Violita, V., Triadiati, T., Miftahudin, M., 2017. Oxidative Stress and Photosynthesis Reduction of Cultivated (*Glycine max* L.) and Wild Soybean (*G. tomentella* L.) Exposed to Drought and Paraquat. Asian J. Plant Sci. 16, 65–77. https://doi.org/10.3923/ajps.2017.65.77

Hansatech Instrument Ltd, 2018. Handy PEA+ and Pocket PEA System Manual.

Heidari, M., 2009. Antioxidant Activity and Osmolyte Concentration of Sorghum (Sorghum bicolor) and Wheat (Triticum aestivum) Genotypes under Salinity Stress. Asian J. Plant Sci. 8, 240–244. https://doi.org/10.3923/ajps.2009.240.244

Heinemann, A.B., Stone, L.F., Fageria, N.K., 2011. Transpiration rate response to water deficit during vegetative and reproductive phases of upland rice cultivars. Sci. Agric. 68, 24–30. https://doi.org/10.1590/S0103-90162011000100004

Hendratno, S., 2015. Analysis of Crumb Rubber SIR Market Developments. War. Perkaretan 34, 161–176. https://doi.org/10.22302/ppk.wp.v34i2.257

Indraty, I.S., 2003. The Endurance of Rubber Planting Material Clones Planted in Polybags on The Drought Condition. Indones. J. Nat. Rubber Res. 21, 12–24.

IPCC, 2018. Summary for Policymakers, in: Masson-Delmotte, V., Zhai, P., Pörtner, H.O., Roberts, D., Skea, J., Shukla, P.R., Pirani, A., Moufouma-Okia, W., Péan, C., Pidcock, R., Connors, S., Matthews, J.B.R., Chen, Y., Zhou, X., Gomis, M.I., Lonnoy, E., Maycock, T., Tignor, M., Waterfield, T. (Eds.), Global Warming of 1.5°C. An IPCC Special Report on the Impacts of Global Warming of 1.5°C above Pre-Industrial Levels and Related Global Greenhouse Gas Emission Pathways, in the Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty. World Meteorological Organization, Geneva, Switzerland, p. 32.

Jedmowski, C., Ashoub, A., Momtaz, O., Brüggemann, W., 2015. Impact of Drought, Heat, and Their Combination on Chlorophyll Fluorescence and Yield of Wild Barley (*Hordeum spontaneum*). J. Bot. 2015, 1–9. https://doi.org/10.1155/2015/120868

Juan, C.A., Pérez de la Lastra, J.M., Plou, F.J., Pérez-Lebeña, E., 2021. The Chemistry of Reactive Oxygen Species (ROS) Revisited: Outlining Their Role in Biological Macromolecules (DNA, Lipids and Proteins) and Induced Pathologies. Int. J. Mol. Sci. 22, 4642. https://doi.org/10.3390/ijms22094642

Junaidi, J., 2020. Improvement of National Rubber Productivity through Acceleration of Innovation Adoption at The Farmer's Level. Perspektif 19, 17–28.

UNIVERSITAS
GADJAH MADA
Identification of Physiological Traits and QTLs Associated with Drought Resistance in Rubber (Hevea brasiliensis Muell. Arg.) using PB 260 x SP 217 Population and Several Control Clones
ANDI NUR CAHYO, Dr. Rudi Hari Murti, S.P., M.P.; Eka Tarwaca Susila Putra, S.P., M.P., Ph.D.; Dr. Pascal Montoro
Universitas Gadjah Mada, 2022 | Diunduh dari http://etd.repository.ugm.ac.id/

Kalaji, H.M., Jajoo, A., Oukarroum, A., Brestic, M., Zivcak, M., Samborska, I.A., Cetner, M.D., Łukasik, I., Goltsev, V., Ladle, R.J., 2016. Chlorophyll a fluorescence as a tool to monitor physiological status of plants under abiotic stress conditions. Acta Physiol. Plant. 38, 1–11. https://doi.org/10.1007/s11738-016-2113-y

Kalaji, H.M., Schansker, G., Ladle, R.J., Goltsev, V., Bosa, K., Allakhverdiev, S.I., Brestic, M., Bussotti, F., Calatayud, A., Dąbrowski, P., Elsheery, N.I., Ferroni, L., Guidi, L., Hogewoning, S.W., Jajoo, A., Misra, A.N., Nebauer, S.G., Pancaldi, S., Penella, C., Poli, D., Pollastrini, M., Romanowska-Duda, Z.B., Rutkowska, B., Serôdio, J., Suresh, K., Szulc, W., Tambussi, E., Yanniccari, M., Zivcak, M., 2014. Frequently asked questions about in vivo chlorophyll fluorescence: practical issues. Photosynth. Res. 122, 121–158. https://doi.org/10.1007/s11120-014-0024-6

Karnatam, K.S., Jaganathan, D., Dilip, K.R., Boopathi N, M., Muthurajan, R., 2020. Shortlisting putative candidate genes underlying qDTY1.1, a major effect drought tolerant QTL in rice (*Oryza sativa* L.). Electron. J. Plant Breed. 11, 916–924. https://doi.org/10.37992/2020.1103.149

Karyudi, 2001. Rubber (*Hevea brasiliensis*) osmoregulation as the respons to water stress I : Variation between recommended, expected, and germplasm. Indones. J. Nat. Rubber Res. 19, 1–17.

Kataria, S., 2017. Oxidative Stress and Antioxidative Defence System in Plants in Response to UV-B Stress, in: Singh, V.P., Singh, S., Prasad, S.M., Parihar, P. (Eds.), UV-B Radiation: From Environmental Stressor to Regulator of Plant Growth. John Wiley & Sons, Ltd, Chichester, UK, pp. 99–122. https://doi.org/10.1002/9781119143611

Kearsey, M.J., 1998. The principles of QTL analysis (a minimal mathematics approach). J. Exp. Bot. 49, 1619–1623.

Kholová, J., Hash, C.T., Kočová, M., Vadez, V., 2011. Does a terminal drought tolerance QTL contribute to differences in ROS scavenging enzymes and photosynthetic pigments in pearl millet exposed to drought? Environ. Exp. Bot. 71, 99–106. https://doi.org/10.1016/j.envexpbot.2010.11.001

Kim, T.-H., Hur, Y.-J., Han, S.-I., Cho, J.-H., Kim, K.-M., Lee, J.-H., Song, Y.-C., Kwon, Y.-U., Shin, D., 2017. Drought-tolerant QTL qVDT11 leads to stable tiller formation under drought stress conditions in rice. Plant Sci. 256, 131–138. https://doi.org/10.1016/j.plantsci.2016.11.008

Kneebone, W.R., Kopec, D.M., Mancino, C.F., 1992. Water Requirements and Irrigation. Turfgrass Agron. Monogr. 441–472.

Kramer, P.J., 1983. Water Relations of Plants. Academic Press Inc., Orlando.

UNIVERSITAS
GADJAH MADA
Identification of Physiological Traits and QTLs Associated with Drought Resistance in Rubber (Hevea brasiliensis Muell. Arg.) using PB 260 x SP 217 Population and Several Control Clones
ANDI NUR CAHYO, Dr. Rudi Hari Murti, S.P., M.P.; Eka Tarwaca Susila Putra, S.P., M.P., Ph.D.; Dr. Pascal Montoro
Universitas Gadjah Mada, 2022 | Diunduh dari http://etd.repository.ugm.ac.id/

Krishan, B., 2017. Assessment of drought tolerance in few clones of natural rubber (*Hevea brasiliensis*) under dry hot climate of Odisha, India. J. Exp. Biol. Agric. Sci. 5, 106–110. https://doi.org/10.18006/2017.5(1).106.110

Kujur, A., Saxena, M.S., Bajaj, D., Laxmi, Parida, S.K., 2013. Integrated genomics and molecular breeding approaches for dissecting the complex quantitative traits in crop plants. J. Biosci. 38, 971–987. https://doi.org/10.1007/s12038-013-9388-6

Lacape, M.J., Wery, J., Annerose, D.J.M., 1998. Relationships between plant and soil water status in five field-grown cotton *Gossypium hirsutum* L. cultivars. Field Crops Res. 57, 29–43.

Lawlor, D.W., 2013. Genetic engineering to improve plant performance under drought: physiological evaluation of achievements, limitations, and possibilities. J. Exp. Bot. 64, 83–108.

Le Guen, V., Garcia, D., Doaré, F., Mattos, C.R.R., Condina, V., Couturier, C., Chambon, A., Weber, C., Espéout, S., Seguin, M., 2011. A rubber tree's durable resistance to *Microcyclus ulei* is conferred by a qualitative gene and a major quantitative resistance factor. Tree Genet. Genomes 7, 877–889. https://doi.org/10.1007/s11295-011-0381-7

Le Guen, V., Garcia, D., Mattos, C.R.R., Doaré, F., Lespinasse, D., Seguin, M., 2007. Bypassing of a polygenic *Microcyclus ulei* resistance in rubber tree, analyzed by QTL detection. New Phytol. 173, 335–345. https://doi.org/10.1111/j.1469-8137.2006.01911.x

Le Guen, V., Lespinasse, D., Oliver, G., Rodier-Goud, M., Pinard, F., Seguin, M., 2003. Molecular mapping of genes conferring field resistance to South American Leaf Blight (*Microcyclus ulei*) in rubber tree. Theor. Appl. Genet. 108, 160–167. https://doi.org/10.1007/s00122-003-1407-9

Leclercq, J., Martin, F., Sanier, C., Clément-Vidal, A., Fabre, D., Oliver, G., Lardet, L., Ayar, A., Peyramard, M., Montoro, P., 2012. Over-expression of a cytosolic isoform of the HbCuZnSOD gene in *Hevea brasiliensis* changes its response to a water deficit. Plant Mol. Biol. 80, 255–272. https://doi.org/10.1007/s11103-012-9942-x

Lekawipat, N., Teerawatanasuk, K., Rodier-Goud, M., Seguin, M., Vanavichit, A., Toojinda, T., Tragoonrung, S., 2003. Genetic Diversity Analysis of Wild Germplasm and Cultivated Clones *Hevea brasiliensis* MuelL Arg. by Using Microsatellite Markers. J. Rubber Res. 6, 36–47.

Lespinasse, D., Grivet, L., Troispoux, V., Rodier-Goud, M., Pinard, F., Seguin, M., 2000. Identification of QTLs involved in the resistance to South American leaf blight (*Microcyclus ulei*) in the rubber tree. Theor. Appl. Genet. 100, 975–984. https://doi.org/10.1007/s001220051379

UNIVERSITAS
GADJAH MADA
Identification of Physiological Traits and QTLs Associated with Drought Resistance in Rubber (Hevea brasiliensis Muell. Arg.) using PB 260 x SP 217 Population and Several Control Clones
ANDI NUR CAHYO, Dr. Rudi Hari Murti, S.P., M.P.; Eka Tarwaca Susila Putra, S.P., M.P., Ph.D.; Dr. Pascal Montoro
Universitas Gadjah Mada, 2022 | Diunduh dari http://etd.repository.ugm.ac.id/

Lestari, R., Rio, M., Martin, F., Leclercq, J., Woraathasin, N., Roques, S., Dessailly, F., Clément-Vidal, A., Sanier, C., Fabre, D., Melliti, S., Suharsono, S., Montoro, P., 2018. Overexpression of Hevea brasiliensis ethylene response factor HbERF-IXc5 enhances growth and tolerance to abiotic stress and affects laticifer differentiation. Plant Biotechnol. J. 16, 322–336. https://doi.org/10.1111/pbi.12774

LI-COR, Inc., 1990. LI-189 Quantum/Radiometer/Photometer Operating Manual.

Luke, L.P., Sathik, M.B.M., Thomas, M., Kuruvilla, L., Sumesh, K.V., Annamalainathan, K., 2015. Quantitative expression analysis of drought responsive genes in clones of Hevea with varying levels of drought tolerance. Physiol Mol Biol Plants 21, 179–186.

Luo, L.J., 2010. Breeding for water-saving and drought-resistance rice (WDR) in China. J. Exp. Bot. 61, 3509–3517. https://doi.org/10.1093/jxb/erq185

Luquet, D., Clément-Vidal, A., Fabre, D., This, D., Sonderegger, N., Dingkuhn, M., 2008. Orchestration of transpiration, growth and carbohydrate dynamics in rice during a dry-down cycle. Funct. Plant Biol. 35, 689–704. https://doi.org/10.1071/FP08027

Marklund, S., Marklund, G., 1974. Involvement of the Superoxide Anion Radical in the Autoxidation of Pyrogallol and a Convenient Assay for Superoxide Dismutase. Eur. J. Plant Biochem. 47, 469–474.

Martins, M.B.G., Zieri, R., 2003. Leaf anatomy of rubber-tree clones. Sci. Agric. 60, 709–713. https://doi.org/10.1590/S0103-90162003000400015

Maxwell, K., Johnson, G.N., 2000. Chlorophyll fluorescence—a practical guide. J. Exp. Bot. 51, 659–668.

Mazid, M., Khan, T.A., Khan, Z.H., Quddusi, S., Mohammad, F., 2011. Occurrence, Biosynthesis and Potentialities of Ascorbic Acid in Plants. Int. J. Plant Anim. Environ. Sci. 1, 167–184.

Medrano, H., 2002. Regulation of Photosynthesis of C3 Plants in Response to Progressive Drought: Stomatal Conductance as a Reference Parameter. Ann. Bot. 89, 895–905. https://doi.org/10.1093/aob/mcf079

Meinke, H., Hammer, G.L., 1995. A peanut simulation model: II. Assesing regional production potential. Agron. J. 87, 1093–1099.

Messmer, R., Fracheboud, Y., Bänziger, M., Stamp, P., Ribaut, J.-M., 2011. Drought stress and tropical maize: QTLs for leaf greenness, plant senescence, and root capacitance. Field Crops Res. 124, 93–103. https://doi.org/10.1016/j.fcr.2011.06.010

Mokhatar, 2011. Performance of *Hevea brasiliensis* on Haplic Ferralsol as Affected by Different Water Regimes. Am. J. Appl. Sci. 8, 206–211. https://doi.org/10.3844/ajassp.2011.206.211

Møller, I.M., 2001. Plant mitochondria and oxidative anitioxidant capacity and resistance to stress : Electron transport, NADPH turnover and photoinhibition in Poplar trees. Plant

UNIVERSITAS
GADJAH MADA
Identification of Physiological Traits and QTLs Associated with Drought Resistance in Rubber (Hevea brasiliensis Muell. Arg.) using PB 260 x SP 217 Population and Several Control Clones
ANDI NUR CAHYO, Dr. Rudi Hari Murti, S.P., M.P.; Eka Tarwaca Susila Putra, S.P., M.P., Ph.D.; Dr. Pascal Montoro
Universitas Gadjah Mada, 2022 | Diunduh dari http://etd.repository.ugm.ac.id/

Physiol., metabolism of reactive oxygen species. Annu. Rev. Plant Physiol. Plant Mol. Biol. 52, 561–591. https://doi.org/10.1146/annurev.arplant.52.1.561

Mueller, M.J., 2004. Archetype signals in plants: the phytoprostanes. Curr. Opin. Plant Biol. 7, 441–448. https://doi.org/10.1016/j.pbi.2004.04.001

Mulyani, E., 2017. Perbandingan Hasil Penetapan Kadar Vitamin C pada Buah Kiwi (*Actinidia deliciousa*) dengan Menggunakan Metode Iodimetri dan Spektrofotometri UV-Vis. Pharmauho J. Farm. Sains Dan Kesehat. 3, 14–17.

Murchie, E.H., Lawson, T., 2013. Chlorophyll fluorescence analysis: a guide to good practice and understanding some new applications. J. Exp. Bot. 64, 3983–3998. https://doi.org/10.1093/jxb/ert208

Murray, M.G., Thompson, W.F., 1980. Rapid isolation of high molecular weight plant DNA. Nucleic Acids Res. 8, 4321–4326. https://doi.org/10.1093/nar/8.19.4321

Nirapathpongporn, K., Kongsawadworakul, P., Viboonjun, U., Teerawattanasuk, K., Chrestin, H., Segiun, M., Clément-Dement, A., Narangajavana, J., 2016. Development and mapping of functional expressed sequence tag-derived simple sequence repeat markers in a rubber tree RRIM600 × PB217 population. Mol. Breed. 36. https://doi.org/10.1007/s11032-016-0461-3

Ögren, E., Sjöström, M., 1990. Estimation of the effect of photoinhibition on the carbon gain in leaves of a willow canopy. Planta 181, 560–557.

Oukarroum, A., Madidi, S.E., Schansker, G., Strasser, R.J., 2007. Probing the responses of barley cultivars (*Hordeum vulgare* L.) by chlorophyll a fluorescence OLKJIP under drought stress and re-watering. Environ. Exp. Bot. 60, 438–446. https://doi.org/10.1016/j.envexpbot.2007.01.002

Patil, H.E., Mahatma, M.K., Patel, N.J., Bhatnagar, R., Jadeja, G.C., 2005. DIfferential Response of Pearl Millet Hybrids to Water Stress in Relation to Antioxidant Enzymes and Proline. Indian J. Plant Physiol. 10, 344–348.

Pinizzotto, S., 2019. The Condition and Outlook of World Natural Rubber Supply and Demand.

Polle, A., Chen, S.L., Eckert, C., Harfouche, A., 2019. Engineering Drought Resistance in Forest Trees. Front. Plant Sci. 9, 1–18.

Pootakham, W., Ruang-Areerate, P., Jomchai, N., Sonthirod, C., Sangsrakru, D., Yoocha, T., Theerawattanasuk, K., Nirapathpongporn, K., Romruensukharom, P., Tragoonrung, S., Tangphatsornruang, S., 2015. Construction of a high-density integrated genetic linkage map of rubber tree (*Hevea brasiliensis*) using genotyping-by-sequencing (GBS). Front. Plant Sci. 6, 1–12. https://doi.org/10.3389/fpls.2015.00367

Price, A., Courtois, B., 1999. Mapping QTLs associated with drought resistance in rice: Progress, problems and prospects. Plant Growth Regul. 29, 123–133.

Identification of Physiological Traits and QTLs Associated with Drought Resistance in Rubber (Hevea brasiliensis Muell. Arg.) using PB 260 x SP 217 Population and Several Control Clones
ANDI NUR CAHYO, Dr. Rudi Hari Murti, S.P., M.P.; Eka Tarwaca Susila Putra, S.P., M.P., Ph.D.; Dr. Pascal Montoro
Universitas Gadjah Mada, 2022 | Diunduh dari http://etd.repository.ugm.ac.id/

Price, A.H., Cairns, J.E., Horton, P., Jones, H.G., Griffiths, H., 2002. Linking drought-resistance mechanisms to drought avoidance in upland rice using a QTL approach: progress and new opportunities to integrate stomatal and mesophyll responses. J. Exp. Bot. 53, 989–1004. https://doi.org/10.1093/jexbot/53.371.989

Priyadarsha, P.M., 2017. Biology of Hevea Rubber. Springer Science+Business Media, New York, NY.

Prochazkova, D., Sairam, R.K., Srivastava, G.C., Singh, D.V., 2001. Oxidative stress and antioxidant activity as the basis of senescence in maize leaves. Plant Sci. 161, 765–771. https://doi.org/10.1016/S0168-9452(01)00462-9

Punchkhon, C., Plaimas, K., Buaboocha, T., Siangliw, J.L., Toojinda, T., Comai, L., De Diego, N., Spíchal, L., Chadchawan, S., 2020. Drought-Tolerance Gene Identification Using Genome Comparison and Co-Expression Network Analysis of Chromosome Substitution Lines in Rice. Genes 11, 1197. https://doi.org/10.3390/genes11101197

Putranto, R.-A., Herlinawati, E., Rio, M., Leclercq, J., Piyatrakul, P., Gohet, E., Sanier, C., Oktavia, F., Pirrello, J., Kuswanhadi, Montoro, P., 2015. Involvement of Ethylene in the Latex Metabolism and Tapping Panel Dryness of *Hevea brasiliensis*. Int. J. Mol. Sci. 16, 17885–17908. https://doi.org/10.3390/ijms160817885

Rallo, G., Provenzano, G., Castellini, M., Sirera, À., 2018. Application of EMI and FDR Sensors to Assess the Fraction of Transpirable Soil Water over an Olive Grove. Water 10, 168. https://doi.org/10.3390/w10020168

Rao, P.S., Saraswathyamma, C.K., Sethuraj, M.R., 1998. Studies on the relationship between yield and meteorological parameters of para rubber tree (*Hevea brasiliensis*). Agric. For. Meteorol. 90, 235–245.

Rao, P.S., Vijayakumar, K.R., 1992. Climatic Requirements, in: Sethuraj, M.R., Mathew, N.M. (Eds.), Natural Rubber: Biology, Cultivation, and Technology, Developments in Crop Science. Elsevier Science Publisher, Amsterdam ; New York, pp. 200–219.

Rattanawong, R., Prapan, K., Lekawipat, N., Teerawatanasuk, K., Kasemsap, P., Seguin, M., Demange, A., 2008. QTLs detection for growth and initial latex production in rubber (Hevea brasiliensis), in: 2008 IRRDB International Natural Rubber Conference and Annual Meetings. Presented at the 2008 IRRDB International Natural Rubber Conference and Annual Meetings, IRRDB, Kuala Lumpur, pp. 1–28.

Rattanawong, R., Teerawattanasuk, K., Prapan, K., Clément-Demange, A., Lekawipat, N., 2011. APPLICATION OF QTL MAPPING FOR EARLY SELECTION ON GROWTH AND LATEX YIELD TRAITS IN RUBBER BREEDING. IRRDB, Chiang Mai, Thailand, pp. 1–10.

Rhodes, D., Hanson, A.D., 1993. Quaternary Ammonium and Tertiary Sulfonium Compounds in Higher Plants. Annu. Rev. Plant Physiol. Plant Mol. Biol. 44, 357–384.

UNIVERSITAS
GADJAH MADA
Identification of Physiological Traits and QTLs Associated with Drought Resistance in Rubber (Hevea brasiliensis Muell. Arg.) using PB 260 x SP 217 Population and Several Control Clones
ANDI NUR CAHYO, Dr. Rudi Hari Murti, S.P., M.P.; Eka Tarwaca Susila Putra, S.P., M.P., Ph.D.; Dr. Pascal Montoro
Universitas Gadjah Mada, 2022 | Diunduh dari http://etd.repository.ugm.ac.id/

Rosa, J.R.B.F., Mantello, C.C., Garcia, D., de Souza, L.M., da Silva, Carla Cristina, Gazaffi, R., da Silva, Cícero Casimiro, Toledo-Silva, G., Cubry, P., Garcia, A.A.F., de Souza, A.P., Le Guen, V., 2018. QTL detection for growth and latex production in a full-sib rubber tree population cultivated under suboptimal climate conditions. BMC Plant Biol. 18. https://doi.org/10.1186/s12870-018-1450-y

Sangsing, K., Cochard, H., Kasemsap, P., Thanisawanyangkura, S., Sangkhasila, K., Gohet, E., Thaler, P., 2004a. Is growth performance in rubber (*Hevea brasiliensis*) clones related to xylem hydraulic efficiency? Can. J. Bot. 82, 886–891. https://doi.org/10.1139/b04-083

Sangsing, K., Roux, X.L., Kasemsap, P., Thanisawanyangkura, S., Sangkhasila, K., Gohet, E., Thaler, P., 2004b. Photosynthetic Capacity and Effect of Drought on Leaf Gas Exchange in Two Rubber (*Hevea brasiliensis*) Clones. Kasetsart J Nat Sci 38, 111–122.

Sanier, C., Oliver, G., Clément-Vidal, A., Fabre, D., Lardet, L., Montoro, P., 2013. Influence of Water Deficit on the Physiological and Biochemical Parameters of in vitro Plants from *Hevea brasiliensis* Clone PB 260. J. Rubber Res. 16, 61–74.

Santos, J., Oliveira, L.E., Tadeu Coelho, V., Lopes, G., Souza, T., Porto, A.C., Lira, J., Massote, R., Rocha, C., Gomes, M.P., 2021. Performance of *Hevea brasiliensis* under drought conditions on osmoregulation and antioxidant activity through evaluation of vacuolar invertase and reducing sugars. Plant Sci. Today 8. https://doi.org/10.14719/pst.2021.8.2.1020

Saputra, J., 2013. Analysis of the Effect of La-Nina 2010 Climate Anomaly in Sembawa Research Centre Experimental Field South Sumatera. Widyariset 16, 377–384.

SAS Institute Inc., 2002. The SAS System for Windows. SAS Institute Inc., Cary, NC, USA.

Sasaki, H., Li, Z., Tsuji, K., Oda, M., 1994. Factors Affecting the Measurement of Chlorophyll a Fluorescence in Cucumber Leaves. Jpn. Agric. Res. Q. 28, 242–246.

Schansker, G., Yuan, Y., Strasser, R.J., 2008. Chl a Fluorescence and 820 nm Transmission Changes Occurring During a Dark-to-Light Transition in Pine Needles and Pea Leaves: A Comparison, in: Allen, J.F., Gantt, E., Golbeck, J.H., Osmond, B. (Eds.), Energy from the Sun. Springer, Dordrecht, pp. 945–949.

Serraj, R., Sinclair, T.R., 2002. Osmolyte accumulation: can it really help increase crop yield under drought conditions? Plant Cell Environ. 25, 333–341.

Shao, H.-B., Chu, L.-Y., Jaleel, C.A., Zhao, C.-X., 2008. Water-deficit stress-induced anatomical changes in higher plants. C. R. Biol. 331, 215–225. https://doi.org/10.1016/j.crvi.2008.01.002

Shearman, J.R., Sangsrakru, D., Jomchai, N., Ruang-areerate, P., Sonthirod, C., Naktang, C., Theerawattanasuk, K., Tragoonrung, S., Tangphatsornruang, S., 2015. SNP

UNIVERSITAS
GADJAH MADA
Identification of Physiological Traits and QTLs Associated with Drought Resistance in Rubber (Hevea brasiliensis Muell. Arg.) using PB 260 x SP 217 Population and Several Control Clones
ANDI NUR CAHYO, Dr. Rudi Hari Murti, S.P., M.P.; Eka Tarwaca Susila Putra, S.P., M.P., Ph.D.; Dr. Pascal Montoro
Universitas Gadjah Mada, 2022 | Diunduh dari http://etd.repository.ugm.ac.id/

Identification from RNA Sequencing and Linkage Map Construction of Rubber Tree for Anchoring the Draft Genome. PLoS ONE 10, e0121961. https://doi.org/10.1371/journal.pone.0121961

Silva, P.E.M., Cavatte, P.C., Morais, L.E., Medina, E.F., DaMatta, F.M., 2013. The functional divergence of biomass partitioning, carbon gain and water use in Coffea canephora in response to the water supply: Implications for breeding aimed at improving drought tolerance. Environ. Exp. Bot. 87, 49–57. https://doi.org/10.1016/j.envexpbot.2012.09.005

Sinclair, T.R., Ludlow, M.M., 1986. Influence of Soil Water Supply on the Plant Water Balance of Four Tropical Grain Legumes. Aust. J. Plant Physiol. 13, 329–341.

Singh, R., Singh, Y., Xalaxo, S., Verulkar, S., Yadav, N., Singh, S., Singh, N., Prasad, K.S.N., Kondayya, K., Rao, P.V.R., Rani, M.G., Anuradha, T., Suraynarayana, Y., Sharma, P.C., Krishnamurthy, S.L., Sharma, S.K., Dwivedi, J.L., Singh, A.K., Singh, P.K., Nilanjay, Singh, N.K., Kumar, R., Chetia, S.K., Ahmad, T., Rai, M., Perraju, P., Pande, A., Singh, D.N., Mandal, N.P., Reddy, J.N., Singh, O.N., Katara, J.L., Marandi, B., Swain, P., Sarkar, R.K., Singh, D.P., Mohapatra, T., Padmawathi, G., Ram, T., Kathiresan, R.M., Paramsivam, K., Nadarajan, S., Thirumeni, S., Nagarajan, M., Singh, A.K., Vikram, P., Kumar, A., Septiningshih, E., Singh, U.S., Ismail, A.M., Mackill, D., Singh, Nagendra K., 2016. From QTL to variety-harnessing the benefits of QTLs for drought, flood and salt tolerance in mega rice varieties of India through a multi-institutional network. Plant Sci. 242, 278–287. https://doi.org/10.1016/j.plantsci.2015.08.008

Smirnoff, N., 1996. The Function and Metabolism of Ascorbic Acid in Plants. Ann. Bot. 78, 661–669.

Souza, L.M., Gazaffi, R., Mantello, C.C., Silva, C.C., Garcia, D., Le Guen, V., Cardoso, S.E.A., Garcia, A.A.F., Souza, A.P., 2013. QTL Mapping of Growth-Related Traits in a Full-Sib Family of Rubber Tree (*Hevea brasiliensis*) Evaluated in a Sub-Tropical Climate. PLoS ONE 8, e61238. https://doi.org/10.1371/journal.pone.0061238

Souza, R.P., Machado, E.C., Silva, J.A.B., Lagôa, A.M.M.A., Silveira, J.A.G., 2004. Photosynthetic gas exchange, chlorophyll fluorescence and some associated metabolic changes in cowpea (Vigna unguiculata) during water stress and recovery. Environ. Exp. Bot. 51, 45–56. https://doi.org/10.1016/S0098-8472(03)00059-5

Stewart, R.R.C., Bewley, J.D., 1980. Lipid Peroxidation Associated with Accelerated Aging of Soybean Axes. PLANT Physiol. 65, 245–248. https://doi.org/10.1104/pp.65.2.245

Stirbet, A., Govindjee, 2011. On the relation between the Kautsky effect (chlorophyll a fluorescence induction) and Photosystem II: Basics and applications of the OJIP

UNIVERSITAS
GADJAH MADA
Identification of Physiological Traits and QTLs Associated with Drought Resistance in Rubber (Hevea brasiliensis Muell. Arg.) using PB 260 x SP 217 Population and Several Control Clones
ANDI NUR CAHYO, Dr. Rudi Hari Murti, S.P., M.P.; Eka Tarwaca Susila Putra, S.P., M.P., Ph.D.; Dr. Pascal Montoro
Universitas Gadjah Mada, 2022 | Diunduh dari http://etd.repository.ugm.ac.id/

fluorescence transient. J. Photochem. Photobiol. B 104, 236–257. https://doi.org/10.1016/j.jphotobiol.2010.12.010

Stirbet, A., Lazár, D., Kromdijk, J., Govindjee, 2018. Chlorophyll a fluorescence induction: Can just a one-second measurement be used to quantify abiotic stress responses? Photosynthetica 56, 86–104. https://doi.org/10.1007/s11099-018-0770-3

Strasser, R.J., Tsimilli-Michael, M., Srivastava, A., 2004. Analysis of the Chlorophyll a Fluorescence Transient, in: Papageorgiou, G.C., Govindjee (Eds.), Chlorophyll a Fluorescence. Springer Netherlands, Dordrecht, pp. 321–362. https://doi.org/10.1007/978-1-4020-3218-9_12

Strauss, A.J., Krüger, G.H.J., Strasser, R.J., Heerden, P.D.R.V., 2006. Ranking of dark chilling tolerance in soybean genotypes probed by the chlorophyll a fluorescence transient O-J-I-P. Environ. Exp. Bot. 56, 147–157. https://doi.org/10.1016/j.envexpbot.2005.01.011

Sumesh, K.V., Satheesh, P.R., Annamalainathan, K., Krishnakumar, R., Thomas, M., Jacob, J., 2011. Physiological Evaluation of A Few Modern Hevea Clones for Intrinsic Drought Tolerance. Nat. Rubber Res. 24, 61–67.

Suzuki, N., Mittler, R., 2006. Reactive oxygen species and temperature stresses: A delicate balance between signaling and destruction. Physiol. Plant. 126, 45–51. https://doi.org/10.1111/j.0031-9317.2005.00582.x

Syafaah, A., Ismawanto, S., Herlinawati, E., 2015. Variability of Growth, Physiology, and Yield of Rubber Progenies (*Hevea brasiliensis* Muell. Arg.) Resulted from Crossing between PB 260 and RRIC 100 Clones. J. Penelit. Karet 33, 210–213.

Syafaah, A., Woraathakorn, N., Plodpai, P., Nualsri, C., Nakkanong, K., 2020. Comparative Growth Performance and Activity of Defense Related Enzymes and Gene Expression in Rubber Clones Against *Rigidoporus microporus* Infection. Pak. J. Biotechnol. 17, 161–172.

Taiz, L., Zeiger, E., 2002. Plant physiology, 3rd ed. Sinauer Associates, Sunderland, Mass.

Thomas, Cahyo, A.N., Ardika, R., 2011. Anticipation and Effort to Cope With La Nina Climate Anomaly in Rubber Plantation, in: Sriwijaya University Agricutural Department Seminar: Role of Science and Technology on Climate Change Anticipation on The Perspective Sustainable Agriculture. Palembang.

Thomas, Lasminingsih, M., 1994. Respons of some rubber clones on drought. War. Perkaretan 12, 1–4.

Thomas, M., Xavier, S.M., Sumesh, K.V., Annamalainathan, K., Nair, D.B., Mercy, M.A., 2015. Identification of Potential Drought Tolerant Hevea Germplasm Accessions using Physiological and Biochemical Parameters. Rubber Sci. 28, 62–69.

UNIVERSITAS
GADJAH MADA
Identification of Physiological Traits and QTLs Associated with Drought Resistance in Rubber (Hevea brasiliensis Muell. Arg.) using PB 260 x SP 217 Population and Several Control Clones
ANDI NUR CAHYO, Dr. Rudi Hari Murti, S.P., M.P.; Eka Tarwaca Susila Putra, S.P., M.P., Ph.D.; Dr. Pascal Montoro
Universitas Gadjah Mada, 2022 | Diunduh dari http://etd.repository.ugm.ac.id/

Torres, M.A., Dangl, J.L., 2005. Functions of the respiratory burst oxidase in biotic interactions, abiotic stress and development. Curr. Opin. Plant Biol. 8, 397–403. https://doi.org/10.1016/j.pbi.2005.05.014

Tran, D.M., Clément-Demange, A., Déon, M., Garcia, D., Le Guen, V., Clément-Vidal, A., Soumahoro, M., Masson, A., Label, P., Le, M.T., Pujade-Renaud, V., 2016. Genetic Determinism of Sensitivity to Corynespora cassiicola Exudates in Rubber Tree (*Hevea brasiliensis*). PLOS ONE 11, e0162807. https://doi.org/10.1371/journal.pone.0162807

Umebese, C.U., Olatimelitin, T.O., Ogunsusi, T.A., 2009. Salicylic acid protects NR activity, growth and proline in amaranth and tomato plants during water deficit. Am. J. Agr Biol. Sci. 4, 224–229.

Van Ooijen, J.W., 2018. JoinMap ® 5, Software for the calculation of genetic linkage maps in experimental populations of diploid species.

Van Ooijen, J.W., 2009. MapQTL ® 6, Software for the mapping of quantitative trait loci in experimental populations of diploid species. Kyazma B. V., Wageningen, Netherlands.

Vanderlip, R.L., Hammer, G.L., Muchow, R.C., 1996. Assesing planting opportunities in semiarid subtropical environments. Agric. Syst. 51, 97–122.

Velázquez-Márquez, S., Conde-Martínez, V., Trejo, C., Delgado-Alvarado, A., Carballo, A., Suárez, R., Mascorro, J.O., Trujillo, A.R., 2015. Effects of water deficit on radicle apex elongation and solute accumulation in Zea mays L. Plant Physiol. Biochem. 96, 29–37. https://doi.org/10.1016/j.plaphy.2015.07.006

Vijayakumar, K.R., Chandrashekar, T.R., Philip, V., 2000. Agroclimate, in: George, P.J., Jacob, C.K. (Eds.), Natural Rubber: Agromanagement and Crop Processing. Rubber Research Institute of India, Kerala.

Vijayakumar, K.R., Dey, S.K., Chandrasekhar, T.R., Devakumar, A.S., Mohankrishna, T., Rao, P.S., Sethuraj, M.R., 1998. Irrigation requirement of rubber trees *Hevea brasiliensis* in the subhumid tropics. Agric. Water Manag. 245–259.

Voorrips, R.E., 2002. MapChart: Software for the Graphical Presentation of Linkage Maps and QTLs. J. Hered. 93, 77–78. https://doi.org/10.1093/jhered/93.1.77

Wang, L., 2014. Physiological and molecular responses to drought stress in rubber tree (Hevea brasiliensis Muell. Arg.). Plant Physiol. Biochem. 83, 243–249. https://doi.org/10.1016/j.plaphy.2014.08.012

Wang, Z., Li, G., Sun, H., Ma, L., Guo, Y., Zhao, Z., Gao, H., Mei, L., 2018. Effects of drought stress on photosynthesis and photosynthetic electron transport chain in young apple tree leaves. Biol. Open 7, bio035279. https://doi.org/10.1242/bio.035279

Waseem, M., Ali, A., Tahir, M., Nadeem, M.A., Ayub, M., Tanveer, A., Ahmad, R., Hussain, M., 2011. Mechanism of Drought Tolerance in Plant and Its Management Through Different Methods. Cont. J. Agric. Sci. 5, 10–25.

UNIVERSITAS
GADJAH MADA
Identification of Physiological Traits and QTLs Associated with Drought Resistance in Rubber (Hevea brasiliensis Muell. Arg.) using PB 260 x SP 217 Population and Several Control Clones
ANDI NUR CAHYO, Dr. Rudi Hari Murti, S.P., M.P.; Eka Tarwaca Susila Putra, S.P., M.P., Ph.D.; Dr. Pascal Montoro
Universitas Gadjah Mada, 2022 | Diunduh dari http://etd.repository.ugm.ac.id/

Watson, G.A., 1989. Climate and Soil, in: Webster, C.C., Baulkwill, W.J. (Eds.), Rubber. Longman Scientific and Technical, pp. 124–164.

Weng, J.H., 2006. Underestimate of PS2 efficiency in the field due to high leaf temperature resulting from leaf clipping and its amendment. Photosynthetica 44, 467–470. https://doi.org/10.1007/s11099-006-0052-3

Wijaya, T., 2008. Kesesuaian Tanah dan Iklim untuk Karet. War. Perkaretan 27, 34–44.

Wu, W., Zhang, X., Deng, Z., An, Z., Huang, H., Li, W., Cheng, H., 2022. Ultrahigh-density genetic map construction and identification of quantitative trait loci for growth in rubber tree (*Hevea brasiliensis*). Ind. Crops Prod. 178, 114560. https://doi.org/10.1016/j.indcrop.2022.114560

Xia, Z., Liu, K., Zhang, S., Yu, W., Zou, M., He, L., Wang, W., 2018. An ultra-high density map allowed for mapping QTL and candidate genes controlling dry latex yield in rubber tree. Ind. Crops Prod. 120, 351–356. https://doi.org/10.1016/j.indcrop.2018.04.057

Xu, Y., Crouch, J.H., 2008. Marker-Assisted Selection in Plant Breeding: From Publications to Practice. Crop Sci. 48, 391. https://doi.org/10.2135/cropsci2007.04.0191

Yadav, D.K., Kumar, S., Choi, E.-H., Chaudhary, S., Kim, M.-H., 2019. Molecular dynamic simulations of oxidized skin lipid bilayer and permeability of reactive oxygen species. Sci. Rep. 9, 4496. https://doi.org/10.1038/s41598-019-40913-y

Yadaw, R.B., Dixit, S., Raman, A., Mishra, K.K., Vikram, P., Swamy, B.P.M., Cruz, Ma.T.S., Maturan, P.T., Pandey, M., Kumar, A., 2013. A QTL for high grain yield under lowland drought in the background of popular rice variety Sabitri from Nepal. Field Crops Res. 144, 281–287. https://doi.org/10.1016/j.fcr.2013.01.019

Younus, H., 2018. Therapeutic potentials of superoxide dismutase. Int. J. Health Sci. 12, 88–93.

Zhang, Y., Du, Z., Han, Y., Chen, X., Kong, X., Sun, W., Chen, C., Chen, M., 2021. Plasticity of the Cuticular Transpiration Barrier in Response to Water Shortage and Resupply in Camellia sinensis: A Role of Cuticular Waxes. Front. Plant Sci. 11, 600069. https://doi.org/10.3389/fpls.2020.600069

Zushi, K., Matsuzoe, N., 2017. Using of chlorophyll a fluorescence OJIP transients for sensing salt stress in the leaves and fruits of tomato. Sci. Hortic. 219, 216–221. https://doi.org/10.1016/j.scienta.2017.03.016