



UNIVERSITAS
GADJAH MADA

Tanggapan Biokemis, Fisiologis dan Pertumbuhan Pentil Kakao (*Theobroma cacao L.*) terhadap Pemupukan Kalsium

YOVI AVIANTO, Eka Tarwaca Susila Putra, S.P., M.P., Ph.D; Ir. Budiastuti Kurniasih, M.Sc., Ph.D.

Universitas Gadjah Mada, 2022 | Diunduh dari <http://etd.repository.ugm.ac.id/>

DAFTAR PUSTAKA

- Adjaloo, M. K., W. Oduro, & B. K. Banful. 2012. Floral phenology of upper amazon cocoa trees: Implications for reproduction and productivity of cocoa. ISRN Agronomy 2012: 1-7.
- Akiyama, T. & A. Nishio. 1997. Sulawesi's cocoa boom: Lessons of smallholder dynamism and a hands-off policy 33: 97-121.
- Alvim, P. 1984. Factors affecting the flowering of cocoa tree. Cocoa Growers Bulletin, 35, 23—31
- Anderson, J. M., & M.J. Cormier. 1978. Calcium-dependent regulation of NAD kinase. Biochem. Biophys. Res. Commun. 84: 595–602.
- Anonim. 2012. Reducing Cherelle Wilt in Cocoa. <https://www.yara.com.gh/crop-nutrition/cocoa/reducing-cherelle-wilt-in-cocoa/>. Diakses pada 28 Januari 2020.
- Anzules-Toala, V., E. Pazmino-Bonilla, L. Alvarado-Huaman, R. Borjas-Ventura, V. Castro-Cepero & A. Julca-Otiniano. 2022. Control of cacao (*Theobroma cacao*) diseases in Santo Domingo de los Tsachilas, Ecuador. Agronomia Mesoamericana 33.
- Arai, M., H. Mori, & H. Imaseki. 1991. Roles of sucrose4-metabolizing enzymes in growth seedlings, purification of acid invertase from growing hypocotyls of mung bean seedlings. Plant Cell Physiol 32: 1292 – 1298.
- Aras, S., H. Keles & E. Bozkurt. 2021. Physiological and histological responses of peach plants grafted onto different rootstocks under calcium deficiency conditions. Scientia Horticulturae 281: 1-8.
- Association Official Agriculture Chemists. 2000. Official Methods of Analysis of AOAC International. 17 th edition, Volume I. p. 2.5-2.37. In Horwitz, W. (Ed.). Agricultural Chemicals, Contaminants, Drugs. AOAC International, Maryland USA.
- Astuti, Y.T.M.; A.A. Prawoto & K. Dewi. 2011. Pengaruh keberadaan tunas, naphthalene acetic acid dan gibberelic acid terhadap perkembangan buah muda kakao. Pelita Perkebunan 27, 11—23.
- Babin R, Djieto-Lordon C, Cilas C, Dibog L, Mahob R, Bilong CB. 2012. True bug (*Heteroptera*) impact on cocoa fruit mortality and productivity. Journal of Economic Entomology 105:1285-1292.
- Badan Pusat Statistik. 2019. Statistik Kakao Indonesia 2018. Badan Pusat Statistik, Jakarta.
- Balai Penelitian Tanah. 2009. Petunjuk Teknis Edisi 2 : Analisis Kimia Tanah, Tanaman, Air, dan Pupuk. Balai Penelitian Tanah, Bogor.
- Balai Penelitian Tanaman Industri. 2019. Layu Pentil pada Tanaman Kakao. <http://balitri.litbang.pertanian.go.id/index.php/berita/info-teknologi/1004-layu-pentil-pada-tanaman-kakao>. Diakses pada 29 Juni 2021.
- Baribault, T. W., R. K. Kobe, & A. O. Firmley. 2012. Tropical tree growth is correlated with soil phosphorus, potassium, and calcium, though not for legumes. Ecological Monographs 82: 189-203.
- Bates, L., R. P. Waldren, & I. D. Teare. 1973. Rapid determination of free proline for water-stress studies. Plant and Soil 39: 205 – 207.
- Bauer, P., R. Elbaum & I. M. Weiss. 2011. Calcium and silicon mineralization in land plants: Transport, structure and function. Plant Science 180: 746-756.
- Bekele, F. L., I. Bekele, D. R. Butler & G. G. Bidaisee. 2006. Patterns of morphological variation in a sample of cacao (*Theobroma cacao L.*) germplasm from the International Cocoa Genebank, Trinidad. *Genetic Resources and Crop Evolution*, 53: 933-948.
- Bekreij, C, J. Janse, B. J. Vangoor & J. D. J. Vandoesburg. 1992. The incidence of calcium-oxalate crystals in fruit walls of tomato *Lycopersicon esculentum* Mill.



Tanggapan Biokemis, Fisiologis dan Pertumbuhan Pentil Kakao (*Theobroma cacao L.*) terhadap Pemupukan Kalsium

YOVI AVIANTO, Eka Tarwaca Susila Putra, S.P., M.P., Ph.D; Ir. Budiastuti Kurniasih, M.Sc., Ph.D.
Universitas Gadjah Mada, 2022 | Diunduh dari <http://etd.repository.ugm.ac.id/>

as affected by humidity, phosphate and calcium supply. Journal of Horticultural Science 67: 45–50.

Beneragama, C.K. & K. Goto. 2010. Chlorophyll a: b Ratio Increases Under Low-light in 'Shade-tolerant' *Euglena gracilis*. Tropical Agricultural Research 22: 12 – 25.

Bos, M.M.; I. Steffan-Dewenter & T. Tscharntk. 2007. Shade tree management affects fruit abortion, insect pests and patho-gens of cacao. Agriculture, Ecosystems and Environment 120: 201-205.

Buccheri, M. & C. Di Vaio. 2006. Relationship among seed number, quality, and calcium content in apple fruits. Journal of Plant Nutrition 27: 1735-1746.

Carr, M. K. V. & G. Lockwood. 2011. The water relations and irrigation requirements of cocoa (*Theobroma cacao L.*): A review. Expl. Agric 47: 653-676.

Chandran, V., E.J. Stollar, K. Lindorff-Larsen, J.F. Harper, W.J. Chazin, C.M. Dobson, B.F. Luisi & J. Christodoulou. 2006. Structure of the Regulatory Apparatus of a Calcium-dependent Protein Kinase (CDPK): A Novel Mode of Calmodulin-target Recognition. Journal of Molecular Biology 357: 400-410.

Cole, J. C., M. W. Smith, C. J. Penn, B. S. Cheary & K. J. Connaghan. 2016. Nitrogen, phosphorus, calcium, and magnesium applied individually or as a slow release or controlled release fertilizer increase growth and yield and affect macronutrient and micronutrient concentration and content of field-grown tomato plants. Scientia Horticulturae 211: 420-430.

Combs J. H., S. I. Long, & J. Scurlock. 1985. Technique in Bioproduction and Photosynthesis. Pratley Journal 1: 223-225.

Dale, M.P. & D.R. Causton. 1992. Use of the chlorophyll a/b ratio as a bioassay for the light environment of a plant. Functional Ecology 6: 190-196.

Darjanto. 1977. Beberapa Catatan Tentang Pembungan dan Pembentukan Buah Cokelat. Menara Perkebunan 45: 95-100.

Dayoud, M., S. D. Tyerman, R. A. Leigh & M. Gillham. 2010. Calcium storage in plants and the implications for calcium biofortification. Protoplasma 247: 215-231.

Demidchik, V., S. Shabala, S. Isayenkov, T.A. Cuin & I. Pottosin. 2018. Calcium transport across plant membranes: mechanisms and functions. New Phytologist 220: 49-69.

Dieter, P., & D. Marne. 1984. A Ca^{2+} , Calmodulin-dependent NAD kinase from corn is located in the outer mitochondrial membrane. J. Biol. Chem. 259: 84–189.

Dolatabadian, A., S. A. M. M. Sanavy, M. Gholamhoseini, A. K. Joghani, M. Majdi, & A. B. Kashkooli. 2013. The role of calcium in improving photosynthesis and related physiological and biochemical attributes of spring wheat subjected to simulated acid rain. Physiol Mol Biol Plants 19: 189-198.

Dwidjopuspito, T. 1986. Soil Moisture Prediction. Faculty of the Graduate School. University of The Phillipines at Los Banos. Filipina. Disertasi.

Fromm, J. 2010. Wood formation of trees in relation to potassium and calcium nutrition. Tree Physiology 30: 1140-1147.

Ganie, M. A., F Akhter, M. Bhat, A. Malik, J. M. Junaid, & M. A. Shah. 2013. Boron-a critical nutrient element for plant growth and productivity with reference to temperate fruits. Curr. Sci. 104, 76–85.

Gattward, J. N., A. A. F. Almeida, J. O. Souza Jr., F. P. Gomes & H. J. Kronzucker. 2012. Physiologia Plantarum 146: 350-362.

Gavrilescu, M. 2014. The Role of Colloidal Systems in Environmental Protection. Elsevier, Amsterdam.

Giel, P. & K. Bojarczuk. 2011. Effects of high concentrations of calcium salts in substrate and its pH on the growth of selected rhododendron cultivars. Acta Societas Botanicorum Poloniae 80: 105-114.

Gupta, S., R. Gopal & M. V. Singh. 2007. Growth and Physiological Changes in Bitter-Gourd Plants Grown with Variable Calcium Supply in Sand Culture. Journal of Plant Nutrition 30: 2051-2059



Tanggapan Biokemis, Fisiologis dan Pertumbuhan Pentil Kakao (*Theobroma cacao L.*) terhadap Pemupukan Kalsium

UNIVERSITAS
GADJAH MADA
YOVI AVIANTO, Eka Tarwaca Susila Putra, S.P., M.P., Ph.D; Ir. Budiastuti Kurniasih, M.Sc., Ph.D.
Universitas Gadjah Mada, 2022 | Diunduh dari <http://etd.repository.ugm.ac.id/>

- Hageman, R. H. & D. P. Hucklesby. 1971. Nitrate reductase from higher plants. *Methods in enzymology* 2: 1- 10.
- Hair, J.F., R.E. Anderson, R.L. Tatham, and W.C. Black. 1998. Multivariate Data Analysis : Structural Equation Modelling. Fifth Edit. Prentice-Hall International.
- Hao, X. & A. P. Papadopoulos. 2004. Effects of calcium and magnesium on plant growth, biomass partitioning, and fruit yield of winter grennhouse tomato. *HortScience* 39: 512-515.
- Harmon, A.C., M. Grabskov & J.F. Harper. 2002. CDPKs – a kinase for every Ca^{2+} signal?. *Trends in Plant Science* 5: 154-159.
- Harrison E. P., N. M. Willingham, J. C. Lloyd, & C. A. Raines. Reduced sedoheptulose-1,7-bisphosphatase levels in transgenic tobacco lead to decreased photosynthetic capacity and altered carbohydrate accumulation. *Planta* 204:27–36.
- Hirschi, K. 2001. Vacuolar $\text{H}^+/\text{Ca}^{2+}$ transport: who's directing the traffic? *Trends in Plant Science* 6: 100–104.
- Hocking, B., S. D. Tyerman, R. A. Burton, & M. Gillham. 2016. Fruit calcium: transport and physiology. *Front. Plant Sci.* 1 : 1-10.
- Hoeflich, K.P. & M. Ikura, M. 2002. Calmodulin in action: diversity in target recognition and activation mechanisms. *Cell* 108: 739–742.
- Huber, S.C. & J.L. Huber. 1996. Role and regulation of sucrose-phosphate synthase in higher plants. *Annu. Rev. Plant Physiol. Plant Mol. Biol.* 47: 431-444.
- Humphries, E. C. 1943. Wilt of cacao fruits (*Theobroma cacao L.*) II. A Preliminary Survey of the carbohydrate metabolism with special reference to wilt susceptibility. *Ann Bot* 7:45-46.
- Humphries, E. C. 1947. Wilt of cacao fruits (*Theobroma cacao*): IV. Seasonal variation in the carbohydrate reserves of the bark, wood of the cacao tree. *Ann Bot* 11 (42): 221-244.
- Humphries, E. C. 1950. Wilt of cacao fruits (*Theobroma cacao*): V. Seasonal variation in potassium, nitrogen, phosphorus, calcium of the bark, wood of the cacao tree. *Ann Bot* 14 (54): 149-164.
- Hyskova, V. & H. Ryslava. 2018. Hyperosmotic versus hypoosmotic stress in plants. *Biochem Anal Biochem* 7: 1-4.
- Jadin, P. & J. Snoeck. 1985. La méthode du diagnostic sol pour calculer les besoins en engrais des cacaoyers. *Café Cacao Thé*, 29: 255-266.
- Jarrett, H. W., Charbonneau, H., Anderson, J. M., McCann, R. O., and Cormier, M. J. 1980. Plant calmodulin and the regulation of NAD kinase. *Ann. N. Y. Acad. Sci.* 356, 119–129.
- Jones, J. B. 1984. Laboratory guide of exercises in conducting soil tests and plant analysis. Benton Laboratories, INC, Athens. Georgia.
- Kaya, C., H. Kirnak, D. Higgs, & K. Saltali. 2002. Supplementary calcium enhances plant growth and fruit yield in strawberry cultivars grown at high (NaCl) salinity. *Scientia Horticulturae* 93: 65-74.
- Kiegle, E., C. A. Moore, J. Haseloff, M. A. Tester & M. R. Knight, "Cell-type-specific calcium responses to drought, salt and cold in the *Arabidopsis* root," *The Plant Journal* 23: 267–278.
- Kim, M.C., W. S. Chung, D.J. Yun & M.J. Cho. 2009. Calcium and calmodulin-mediated regulation of gene expression in plants. *Molecular Plant* 2: 13-21.
- Kjeldahl, J. 1883. New method for the determination of nitrogen in organic substances. *Zeitschrift für analytische Chemie* 22: 366-383.
- Kohler, J., E. Komor, M. Thom, & A. Maretzki. 1988. Activity of sucrose phosphate synthase in sugarcane leaves. *Phytochemistry* 27 : 1605-1608.
- Krauss, U., V. Adonijah, C. Arroyo, M. Bekker, J. Crozier, A. Gamboa, C. Steuen & K. Holmes. 2012. Cocoa (*Theobroma cacao*) yield increase in Costa Rica through novel stress management and fertilization approach. *Greener Journal of Agricultural Sciences* 2: 68-78.



Tanggapan Biokemis, Fisiologis dan Pertumbuhan Pentil Kakao (*Theobroma cacao L.*) terhadap Pemupukan Kalsium

YOVI AVIANTO, Eka Tarwaca Susila Putra, S.P., M.P., Ph.D; Ir. Budiastuti Kurniasih, M.Sc., Ph.D.
Universitas Gadjah Mada, 2022 | Diunduh dari <http://etd.repository.ugm.ac.id/>

- Kreimer, G., M. Melkonian, J. A. M. Holtum, & E. Latzko. 1988. Stomal free calcium concentration and light-mediated activation of chloroplast fructose-1,6-bisphosphatase. *Plant Physiol* 86: 423–428.
- Kumar, R. 2011. Boron deficiency disorders in mango (*Mangifera indica*): field screening, nutrient composition and amelioration by boron application. *Indian J. Agric. Sci.* 51, 751–754.
- Kwak, J. M., I. C. Mori, Z. M. Pei, N. Leonhardt, M. A. Torres, J. L. Dangl, R. E. Bloom, S. Bodde, J. D. Jones, & J. J. Schroeder. 2003. NADPH oxidase AtrbohD and AtrbohF genes function in ROS-dependent ABA signaling in *Arabidopsis*. *EMBO J.* 22: 2623–2633.
- Lachenaud P, Mooleedhar V, Couturier C. 1997. Les cacaoyers spontanés de Guyane. Nouvelles prospections. *Plant Rech. Dév.* 4:25-30.
- Lamb, E.G., S.J. Shirtliffe & W.E. May. 2011. Structural equation modeling in the plant sciences: An example using yield components in oat. *Canadian Journal of Plant Science* 91: 603-619.
- Leijon, F., M. Melzer, Q. Zhou, V. Srivastava & V. Bulone. 2018. Proteomic analysis of plasmodesmata from populus cell suspension cultures in relation with callose biosynthesis. *Front Plant Science* 9: 16-81.
- Liu, Y. Z., Li, S., C. Q. Yang, and S. A. Peng. 2013. Effects of boron-deficiency on anatomical structures in the leaf main vein and fruit mesocarp of pummelo [*Citrus grandis* (L.) Osbeck]. *Korean J. Hortic. Sci.* 88, 693–700.
- Liu, T.W. F.H. Wu, W.H. Wang, J. Chen, Z.J. Li, X.J. Dong, J. Patton, Z.M. Pei, H.L. Zheng & H.Rennenberg. 2011. Effects of calcium on seed germination, seedling growth and photosynthesis of six forest tree species under simulated acid rain. *Tree Physiology* 31: 402-413.
- Love, N. R., Pollak, N., Dolle, C., Niere, M., Chen, Y., Oliveri, P. 2015. NAD kinase controls animal NADP biosynthesis and is modulated via evolutionarily divergent calmodulin-dependent mechanisms. *Proc. Natl. Acad. Sci. U.S.A.* 112, 1386–1391.
- Lunn, J.E. & E. MacRae. 2003. New complexities in the synthesis of sucrose. *Current Opinion in Plant Biology* 6: 208-214.
- Maiti, R., P. Satya, & A. Ramaswamy. 2012. *Crop Plant Anatomy*. GPI Group, United Kingdom.
- McLaughlin, S. B. & R. Wimmer. 1999. Calcium physiology and terrestrial ecosystem processes. *New Phytologist* 142: 373–417.
- Melnick, R. L., M. D. Strem, J. Crozier., R. C. Sicher, & B. A. Bailey. 2013. Molecular and metabolic changes of cherelle wilt of cacao and its effect on *Moniliophthora roreri*. *Physiological and Molecular Plant Pathology* 84: 153-162.
- Miedema, H., J.H.F. Bothwell, C. Brownlee & J.M. Davies. 2001. Calcium uptake by plant cells – channels and pumps acting in concert. *Trends in Plant Science* 11: 514-519.
- Minimol, J.S., B. Suma, T.K. Shija & K.S. Shilpa. 2020. Genotypic and seasonal variations affecting yield attributes of cocoa (*Theobroma cacao L.*) varieties. *Journal of Agrometeorology* 22: 528-531.
- Mishra, A., M.K. Srivastava & S.P. Shukla. 1991. Plant invertases sensitivity to calcium ions. *Indian J. Plant Physiol* 34: 113-121.
- Misra, N. & A. K. Gupta. 2006. Interactive effects of sodium and calcium on proline metabolism in salt tolerant green gram cultivar. *American Journal of Plant Physiology* 1: 1-12.
- Mosa, W. F. A. E., N.A. A. El-Megeed & L. S. Paszt. 2015. The effect of the foliar application of potassium, calcium, boron and humic acid on vegetative growth, fruit set, leaf mineral, yield and fruit quality of 'anna' apple trees. *American Journal of Experimental Agriculture* 8: 224-234.



Tanggapan Biokemis, Fisiologis dan Pertumbuhan Pentil Kakao (*Theobroma cacao L.*) terhadap Pemupukan Kalsium

YOVI AVIANTO, Eka Tarwaca Susila Putra, S.P., M.P., Ph.D; Ir. Budiastuti Kurniasih, M.Sc., Ph.D.

Universitas Gadjah Mada, 2022 | Diunduh dari <http://etd.repository.ugm.ac.id/>

- Mulder, D. 1953. Les elements mineurs en culture fruitiere. Convegno Nazionale Frutticoltura.
- Muto, S. 1982. Distribution of calmodulin within wheat leaf cells. FEBS LETTERS 147: 161-164.
- Nakagami, H., N. Sugiyama, K. Mochida, A. Daudi, Y. Yoshida, T. Toyoda, M. Tomita, Y. Ishihama & K. Shirasu. 2010. Large-Scale Comparative Phosphoproteomics Identifies Conserved Phosphorylation Sites in Plants. Plant Physiology 153: 1161-1174.
- Nichols, R. 1961. Xylem occlusions in the fruit of cacao (*Theobroma cacao*) and their relation to cherelle wilt. Annals of Botany 25: 463-475.
- Noordiana, N., S. R. S. Omar, J. Shamsuddin, & N. M. N. Aziz. 2007. Effect of organic-based and foliar fertilisers on cocoa (*Theobroma cacao L.*) grown on an oxisol in Malaysia. Malaysian Journal of Soil Science 11 : 29-43.
- Olsen, S. R., C. V. Cole, F. S. Watanabe & L. A. Dean. 1954. Estimation of available P in soils by extraction with sodium bicarbonate. USDA cir. 939: 242-246.
- Pagnussat, G.C., D.F. Fiol & G.L. Salerno. 2002. A CDPK type protein kinase is involved in rice SPS light modulation. Physiologia Plantarum 115: 183-189.
- Parvej, M.R.; N.A. Slaton; T.L. Roberts; R.E. DeLong; C.G. Massey; R.J. Dempsey & M.S. Fryer (2013). Dry matter and potassium accumulation and partitioning in determinate and indeterminate soybean varieties Sabbe Arkansas. In: W.E. Sabbe (Eds.). Soil Fertility Studies. pp. 34–42.
- Poni, S., A. N. Lakso, C. Intrieri, B. Rebucci & I. Filipetti. 2015. Laser scanning estimation of relative light interception by canopy components in different grapevine training systems. VITIS-Journal of Grapevine Research 35: 177-182.
- Proseus, T. E., & J. S. Boyer. 2012. Pectate chemistry links cell expansion to wall deposition in *Chara corallina*. Plant Signal Behav 7: 1490-1492.
- Pusat Penelitian Kopi dan Kakao Indonesia. 2015. Pedoman Teknis Budidaya Tanaman Kakao (*Theobroma cacao L.*). Pusat Penelitian Kopi dan Kakao Indonesia. Jember.
- Raja, M. E., S. C. Anil Kumar, & S. Y. Raju. 2005. Boron deficiency in mango (*Mangifera indica L.*): a cause delineation study in acidic soils of Maharashtra. Indian Soil Sci. Plant Nutr. 51: 751–754.
- Ranade-Malvi, U. 2011. Interaction of micronutrients with major nutrients with special reference to potassium. Karnataka J. Agric. Sci.,24 : 106-109.
- Reddy, V. S., G. S. Ali, & A. S. Reddy. 2002. Genes encoding calmodulin-binding proteins in the *Arabidopsis* genome. J. Biol. Chem.277: 9840–9852.
- Rubiyo, R. & S. Siswanto. 2012. Peningkatan produksi dan pengembangan kakao (*Theobroma cacao L.*) di Indonesia. Jurnal Tanaman Industri dan Tanaman Penyegar 3: 33-48.
- Ruf, F., P. Ehret, & Yoddang. 1996. Smallholder cocoa in indonesia: Why a cocoa boom in sulawesi?. Cocoa Pioneer Fronts: 212-231.
- Sahin, S, N. Gebologlu & M.R. Karaman. 2015. Interactive effect of calcium and boron on growth, quality and mineral content of tomato (*Solanum Lycopersicon L.*). Fresenius Environmental Bulletin 24:1624-1628.
- Salerno, G.L. & L. Curatti. 2003. Origin of sucrose metabolism in higher plants: when, how and why?. Trends in Plant Science 8: 63-69.
- Savini, I., P.C. Smithson & N.K. Karanja. 2006. Effects of added biomass, soil pH and calcium on the solubility of Minjingu phosphate rock in a Kenyan Oxisol. Archives of Agronomy and Soil Science 52: 19-36.
- Sawitri, W.D. & B. Sugiharto. 2018. Rekayasa Sucrose Phosphate Synthase Untuk Meningkatkan Sukrosa Sebagai Sumber Karbon dan Energi Bagi Pertumbuhan Tanaman. Bunga Rampai Forum Peneliti Muda Indonesia 2018. ITB Press, Bandung.



Tanggapan Biokemis, Fisiologis dan Pertumbuhan Pentil Kakao (*Theobroma cacao L.*) terhadap Pemupukan Kalsium

YOVI AVIANTO, Eka Tarwaca Susila Putra, S.P., M.P., Ph.D; Ir. Budiastuti Kurniasih, M.Sc., Ph.D.
Universitas Gadjah Mada, 2022 | Diunduh dari <http://etd.repository.ugm.ac.id/>

Saykhul, A., Chatzissavvidis, C., Therios, I., Dimassi, K., & T. Chatzistathis. 2014.

Growth and nutrient status of olive plants as influenced by foliar potassium applications. *Journal of soil science and plant nutrition.* 14: 602-615.

Schimtz-Eiberger, M., R. Haefs & G. Noga. 2002. Calcium deficiency-influence on the antioxidative defense system in tomato plants. *J. Plant Physiol.*, 159: 733-742.

Scroth, G., P. Laderach, A. I. Martinez-Valle, C. Bunn & L. Jassogne. 2016. Vulnerability to climate change of cocoa in West Africa: Patterns, opportunities and limits to adaptation. *Science of The Total Environment* 556: 231-241.

Simkin, A.J., P.E. Lopez-Calcagno & C.A. Raines. Feeding the world: Improving photosynthetic efficiency for sustainable crop production. *Journal of Experimental Botany* 70: 1119-1140.

Strynadka, N.C., & M.N. James. 1989. Crystal structures of the helix-loop-helix calcium-binding proteins. *Annu Rev Biochem* 58: 95-98.

Tai, L., B. Li, X. Nie, P. Zhang, C. Hu, L. Zhang, W. Liu, W. Li & K. Chen. 2019. Calmodulin Is the Fundamental Regulator of NADK-Mediated NAD Signaling in Plants. *Plant Sci.* 10:681.

Tan, W., Q. W. Meng, M. Brestic, K. Olosovska, X. Yang. 2011. Photosynthesis is improved by exogenous calcium in heat-stressed tobacco plants. *Journal of Plant Physiology* 168: 2063-2071.

Tanaka, A. & H. Tsuji. 1980. Effects of calcium on chlorophyll synthesis and stability in the early phase of greening in cucumber cotyledons. *Plant Physiol* 65: 1211-1215.

Tanaka, A. & R. Tanaka. 2006. Chlorophyll metabolism. *Current Opinion in Plant Biology* 9: 248-255.

Thong, K. & W. Ng. 1978. Growth and nutrients composition of monocrop cocoa plants on inland Malaysian soils. International Conference on Cocoa and Coconuts, pp. 262-286. Kuala Lumpur.

Tognetti, J. A., H.G. Pontis & G.M.A. Martinez-Noel. 2013. Sucrose signaling in plants: A world yet to be explored. *Plant Signaling & Behavior* 8: 1-11.

Toroser, D. & S.C. Huber. 1997. Protein phosphorylation as a mechanism for osmotic-stress activation of sucrose-phosphate synthase in spinach leaves. *Plant Physiol* 114: 947-955.

Torres, M. A., J. L. Dangl, & J. D. Jones. 2002. *Arabidopsis* gp91phox homologues AtrbohD and AtrbohF are required for accumulation of reactive oxygen intermediates in the plant defense response. *Proc. Natl. Acad. Sci.* 99: 517-523.

Tyureteva, E., A. Ivanova & O. Voitsekhovskaja. 2014. On the role of chlorophyll b in ontogenetic adaptations of plants. *Biology Bulletin Reviews* 4:507-514.

United States Departement of Agriculture. 2004. Soil Survey Laboratory Methods Manual. p.167-365.

Uthaiah B. C. & U. V. Sulladmath. 1980. Cytokinin-like substances and cherelle wilt in cacao (*Theobroma cacao L.*). *Journal of Plantation Crops* 8: 78-81.

Valle, R. R., A. A. de Almeida, R. M. De O'Leite. 1990. Energy costs of flowering, fruiting, and cherelle wilt in cacao. *Tree Physiol* 6: 329-336.

Verter, N. 2016. Cocoa export performance in the world's largest producer. *Bulgarian Journal of Agricultural Science* 22: 713-721.

Walingkas, S.A.F. & M. Rantung. 2012. Respon naphtalen acetic acid dan unsur mikro mikombi super terhadap cherelle wilt pada tanaman kakao. *Eugenia* 18: 154-160.

Walkey, A. & I. A. Black. 1934. An examination of degtjareff method for determination of soil organic matter and a proposed modification of the chromic acid in soil analysis I. *Exp J Soil Sci* 79: 459-465.

Wan, G., U. Najeeb, G. Jilani, M. S. Naeem, & W. Zhou. 2011. Calcium invigorates the cadmium-stressed *Brassica napus* L. plants by strengthening their



Tanggapan Biokemis, Fisiologis dan Pertumbuhan Pentil Kakao (*Theobroma cacao L.*) terhadap Pemupukan Kalsium

YOVI AVIANTO, Eka Tarwaca Susila Putra, S.P., M.P., Ph.D; Ir. Budiastuti Kurniasih, M.Sc., Ph.D.
Universitas Gadjah Mada, 2022 | Diunduh dari <http://etd.repository.ugm.ac.id/>

- photosynthetic system. Environmental Science and Pollution Research 18: 1478–1486.
- Wang, N., C. Yang, Z. Pan, Y. Liu & S. Peng. 2015. Boron deficiency in woody plants: various responses and tolerance mechanisms. fORNT. Plant Sci 6: 1-14.
- Wang, W., H. Zhou, B. Ma, A. Owiti, S. S. Korban & Y. Han. 2016 Divergent Evolutionary Pattern of Sugar Transporter Genes is Associated with the Difference in Sugar Accumulation between Grasses and Eudicots. Scientific Reports 6: 1-13.
- Wang, Q., S. Yang, S. Wan & X. Li. 2019. The significance of calcium in photosynthesis. Int. J. Mol. Sci. 2019, 20(6), 1353.
- Wardiana, E., E. Randriani & N.K. Izzah. 2009. Korelasi dan analisis lintasan beberapa karakter penting koleksi plasma nutfah piretrum (*Chrysanthemum cinerariaefolium* Trev.) di kebun percobaan Gunung Putri. Jurnal Litri 15: 1-8.
- Wessel, M. 1985. Shade and Nutrition. In Cocoa, 166-194 (Eds. G.A.R. Wood and A. Lass). Harrow, U.K.: Longman Scientific & Technical.
- White, P. J. & M. R. Broadley. 2003. Calcium in Plants. Annals of Botany 92: 487-511.
- Wimmers, L.E., N.N. Ewing & A.B. Bennett. 1992. Higher plant Ca(2+)-ATPase: primary structure and regulation of mRNA abundance by salt. Proc Natl Acad Sci U S A. 89: 9205–9209.
- Yang, T. & B.W. Poovaiah. 2003. Calcium/calmodulin-mediated signal network in plants. Trends in Plant Science 8: 505-512.
- Yang, B.M., L.X. Yao, G.L. Li, Z.H. He & C.M. Zhou. Dynamic changes of nutrition in litchi foliar and effects of potassium–nitrogen fertilization ratio. Journal of Soil Science and Plant Nutrition, 2015, 15: 98-110.
- Yao, Q., Ge, H., Wu, S., Zhang, N., Chen, W., Xu, C., Gao, J., Thelen, J.J. and Xu, D., 2014. P3DB 3.0: from plant phosphorylation sites to protein networks. Nucleic Acids Research 42: 1206-1213.
- Young, A.M. 1982. Effects of shade cover and availability of midge breeding sites on pollinating midge populations and fruit set in two cocoa farms. Journal of Applied Ecology 19: 47-63.
- Yurtseven, E., Kesmez, G.D., Ünlükara, A. 2005. The effects of water salinity and potassium levels on yield, fruit quality and water consumption of a native central anatolian tomato species (*Lycopersicon esculantum*). Agricultural Water Management. 78: 128-135.
- Zheng, Y., X. Jia, Q. Yang, Y. Liu, R. Xie, Y. Ma, S. He & L. Deng. 2016. Role of Ca²⁺ and calmodulin in on-tree oleocellosis tolerance of Newhall navel orange. Acta Physiologiae Plantarum 38: 1-7.
- Zohlen, A. & G. Tyler. 2000. Immobilization of tissue iron on calcareous soil: differences between calcicole and calcifuge plants. Oikos 89: 95-106.