



Ekofisiologi Kebutuhan Air dan Nutrisi Tanaman Kakao



**EKOFISIOLOGI,
KEBUTUHAN AIR DAN NUTRISI
TANAMAN KAKAO**

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DAFTAR PUSTAKA

- Abbas BS, Dja'far D. 1989. *Sensitivity Analysis of Cacao Cultivation: Relative Profitability of Coconut and Leucaena glauca L. (L. leucocephala) as Shade Plants, Based on a Case Study at Bah Lias Plantation, North Sumatra*. Bull. Perkebunan 20:97-103.
- Abbass, Z. & Y. Okon. 1993. *Physiological Properties of Azotobacter Paspali in Culture and the Rhizosphere*. Soil Biol. Biochem. 8: 1061-1073.
- Abo-Hamed S, Collin HA, Hardwick K. 1981. *Biochemical and Physiological Aspects of Leaf Development in Cocoa (Theobroma cacao L.)*. VI. *Hormonal Interaction between Mature Leaves and the Shoot Apex*. New Phytol. 89:191-200
- Abo-Hamed S, Collin HA, Hardwick K. 1983. *Biochemical and Physiological Aspects of Leaf Development in Cocoa (Theobroma cacao L.)*. VII. *Growth, Orientation, Surface Structure and Water Loss from Developing Flush Leaves*. New Phytol. 95:9-17.
- Abo-Hamed S, Collin HA, Hardwick K. 1984. *Biochemical and Physiological Aspects of Leaf Development in Cocoa (Theobroma cacao L.)*. VIII. *Export and Distribution of ¹⁴C Auxin and Cytokinin from the Young and Mature Leaves*. New Phytol. 97:219-225.
- Acheampong, K. 2010. *A physiological Study on Field Establishment of Cacao Clones Through the Improvement of Agro-Ecological Conditions*. PhD Thesis, University of Reading, UK.
- Acheampong, K., Daymond, A. J. and Hadley, P. 2009. *The Physiological Basis of the Shade Requirement of Young Clonal Cocoa*. Paper Presented at the International Cocoa Research Conference, Bali, November 2009.
- Acquaye, D. 1963. *Some Significance of Soil Organic Phosphorus Mineralization in the Phosphorus Nutrition of Cocoa in Ghana*. Plant and Soil, 19, 65-80.
- Acquaye, D.K. 1964. *Foliar Analysis as a Diagnostic Technique in Cocoa Nutrition. I.—Sampling Procedure and Analytical Methods*. Journal of the Science of Food and Agriculture, **15**, 855-863.
- Acquaye, D.K., Smith, R.W. & Lockard, R.G. 1965. *Potassium Deficiency in Unshaded Amazon Cocoa (Theobroma cacao L.) in Ghana*. Journal of Horticultural Science, **40**, 100-108.
- Adejobi KB, Famaye AO, Adeniyi DO, Akanbi OS and Orisajo SB. 2011. *Comparative Effect of Organo-Mineral Fertilizer and Cocoa Pod Husk Ash on the Soil, Leaf Chemical Composition and Growth Performance of Cacao (Theobroma cacao L.) in South-Western Nigeria*. Obeche Journal 29(1):

212-217.

- Adejobi, K., Akanbi, O., Ugioro, O., Adeosun, S., Mohammed, I., Nduka, B. & Adeniyi, D. 2014. *Comparative Effects of NPK Fertilizer, Cowpea Pod Husk and some Tree Crops Wastes on Soil, Leaf Chemical Properties and Growth Performance of Cocoa (Theobroma cacao L.)*. African Journal of Plant Science, 8, 103-107.
- Adejumo, T.O. 2005. *Crop Protection Strategies for Major Diseases of Cocoa, Coffee and Cashew in Nigeria*. African Journal of Biotechnology, 4, 143-150.
- Adejuwon, J.O. & Ekanade, O. 1987. *Edaphic Component of the Environmental Degradation Resulting from the Replacement of Tropical Rain Forests by Field and Tree Crops in SW Nigeria*. International Tree Crops Journal, 4, 269-282.
- Adi A.P, Endri M. 2014. *Petunjuk Budidaya Kakap pada Kebun Campuran*. Pusat Penelitian Kopi dan Kakao Indonesia (Indonesian Coffee and Cocoa Research Institute) bekerja sama dengan AGFOR SULAWESI.
- Agbeniyi, S., Oluyole, K. & Ogunlade, M. 2011. *Impact of Cocoa Pod Husk Fertilizer on Cocoa Production in Nigeria*. World Journal of Agricultural Sciences, 7, 113-116.
- Agrotrópica 12:67-74. Leite JO, Cadima Zevallos AC. 1991. *Rainwater, Water Table and Soil Moisture in a Hillslope*. In: Proc. Int. Conf. Rain Water Cistern Syst., Keelung, Taiwan, pp.381-386. Leite JO, Valle RR (2000) *Relações entre a precipitação, o lençol freático e a produção de cacau na Bahia*. Agrotrópica 12:67-74.
- Ahenkorah Y, Akrofi GS, Adri AK. 1974. *The end of the First Cocoa Shade and Manurial Experiment at the Cocoa Research Institute of Ghana*. J. Hort. Sci. 49:43-51.
- Ahenkorah Y, Halm BJ, Appiah MR, Akrofi GS, Yirenkyi JEK. 1987. *Twenty Years' Results from a Shade and Fertilizer Trial on Amazon Cocoa (Theobroma cacao) in Ghana*. Exp. Agric. 23:31-39.
- Ahenkorah, Y. & Akrofi, G.S. 1968. *Amazon Cacao (Theobroma cacao L.) Shade and Manurial Experiment (K2- 01) at the Cocoa Research Institute of Ghana*. I. First five years. Agronomy Journal, 60, 591-594.
- Ahenkorah, Y. & Akrofi, G.S. 1969. *Recent Results on Fertilizer Experiments on Shaded Cacao (Theobroma cacao L.) in Ghana*. Rep. 3rd Int. Cocoa Res. Conf., pp. 65-78. Accra, Ghana
- Ahenkorah, Y. & Akrofi, G.S. 1969. *Recent Results on Fertilizer Experiments on Shaded Cacao (Theobroma cacao L.) in Ghana*. Rep. 3rd Int. Cocoa Res. Conf., pp. 65-78. Accra, Ghana.
- Ahenkorah, Y., Akrofi, G. & Adri, A. 1974. *The end of the First Cocoa Shade and*

- Manurial Experiment at the Cocoa Research Institute of Ghana*. Journal of Horticultural Science, 49, 43-51.
- Ahenkorah, Y., Halm, B., Appiah, M., Akrofi, G. & Yirenkyi, J. 1987. *Twenty Years' Results from a Shade and Fertilizer Trial on Amazon Cocoa (Theobroma cacao) in Ghana*. Experimental Agriculture, 23, 31-39.
- Ahmad, I, F. Ahmad and J. Pichtel. 2011. *Microbes and Microbial Technology, Agricultural and Environmental Applications*. ISBN 978-1-4419-7930-8 e-ISBN 978-1-4419-7931-5 Springer New York Dordrecht Heidelberg London.
- Ahn, P. 1993. *Tropical Soils and Fertiliser Use*. Longman Scientific & Technical, England.
- Aikpokpodion, P. 2010. *Nutrients Dynamics in Cocoa Soils, Leaf and Beans in Onto State, Nigeria*. Journal of Agricultural Science, 1, 1-9.
- Alemanno L, Ramos T, Gargadenec A, Andary C, Ferriere N. 2003. *Localization and Identification of Phenolic Compounds in Theobroma cacao L. Somatic Embryogenesis*. Ann. Bot. 92:613-623.
- Ali, F. M. 1969. *Effects of Rainfall on Yield of Cocoa in Ghana*. Experimental Agriculture 5:209–213.
- Allen RC. 2007. *A Pessimist's Guide to the British Industrial Revolution*. Oxford University, Department of Economics Working Paper No. 315.
- Allen, R. G., Pereira, L. S., Raes, D. and Smith, M. 1998. *Crop Evapotranspiration: Guidelines for Computing Crop Water Requirements*. Food and Agricultural Organisation of the United Nations, Irrigation and Drainage Paper 56, Rome, Italy.
- Allison, F.E. 1973. *Soil Organic Matter and It's Role in Crop Production*. Elsevier Scientific Publishing Company. New York. p. 174- 191.
- Almeida A-A F, Valle R R. 2008. *Ecophysiology of the Cacao Tree*. Departamento de Ciências Biológicas, Universidade Estadual de Santa Cruz, 45662-000 Ilhéus, BA, Brasil. Centrode Pesquisas do Cacau, CEPLAC, C.P. 07, 45650-000 Ilhéus, BA, Brasil, raul@cepec.gov.
- Almeida A-AF, Brito RCT, Aguilar MAG, Valle RR. 2002b. *Water Relations' Aspects of Theobroma cacao L. Clones*. Agrotrópica 14:35-44.
- Almeida A-AF, Valle RR. 1995. *Análise de Crescimento do Fruto e Das Sementes de Sete Genótipos de Theobroma cacao L*. Pesq. Agropec. Bras. 30:909-916
- Almeida CMVC, Müller MW, Sena-Gomes AR, Matos PGG. 2002a. *Sistem as Agroflorestais Com o Cacaueiro Como Alternativa Sustentável Para uso em Areas Desmatadas, No Estado de Rondônia, Brasil*. Agrotrópica 14:109-120.
- Almeida HA, Machado RCR, Villa Nova NA, Silva WS. 1987. *Influência de*

- Elementos Meteorológicos no Lançamento Foliar do Cacaueiro*. Rev. Theobroma 17:163-174.
- Alpizar, L., Fassbender, H.W., Heuvelop, J., Fölster, H. & Enríquez, G. 1986. *Modelling Agroforestry Systems of Cacao (Theobroma cacao) with Laurel (Cordia alliodora) and Poro (Erythrina poeppigiana) in Costa Rica*. Agroforestry Systems, **4**, 175-189.
- Alverson WS, Whitlock BA, Nyffeler R, Bayer C, Baum DA. 1999. *Phylogeny of the Core Malvales: Evidence from ndhF Sequence Data*. Am. J. Bot. 86:1474-1486.
- Alvim PT. 1973. *Pesquisas Com o Cacaueiro no Brasil*. Ciên. Cult. 25:409-424.
- Alvim PT. 1989a. *Tecnologias Apropriadas Para a Agricultura Nos Trópicos Umidos*. Agrotrópica 1:5-26.
- Alvim PT. 1954. *Studies on the Cause of Cherelle Wilt of Cacao*. Turrialba 4:72-78.
- Alvim PT. 1959. *El Problema del Sombreamiento del Cacao Desde el Punto de Vista Fisiológico*. In: Proc. 7a Conf. Interamer. de Cacao, Palmira, Colombia, pp. 294-303.
- Alvim PT. 1960. *Las Necesidades de Agua del Cacao*. Turrialba 10:6-16.
- Alvim PT, Alvim R. 1978. *Relation of Climate to Growth Periodicity in Tropical Trees*. In: Tomlinson PB, Zimmermann MH (eds), *Tropical Trees as Living Systems*, pp.445-464. Cambridge University Press, Cambridge.
- Alvim PT, and Pereira CP. 1965. *Sombra e Espaçamento Nas Plantações de Cacao no Estado da Bahia e Centro de Pesquisas do Cacao*. In: *Relatório Anual, Ceplac/ Cepec, Ilhéus, Brasil*, pp.18-19.
- Alvim PT, Machado AD, Vello F. 1974a. *Physiological Responses of Cacao Alvim PT. 1988. Relações Entre Fatores Climáticos e Produção do Cacaueiro*. In: Proc. 10th Int. Cocoa Res. Conf., Santo Domingo, Dominican Republic, pp.159-167.
- Alvim R. 1989b. *O Cacaueiro (Theobroma cacao L.) em Sistem as Agrossilviculturais*. Agrotrópica 1:89-103. Alvim R, Alvim PT. 1976. *Hidroperiodicidade dos Fluxos Foliares do Cacaueiro*. In: Informe Técnico, Ilhéus, Brasil, pp.42-48.
- Alvim R, Alvim PT, Lorenzi R, Saunders PF. 1974. *The Possible Role of Abscisic Acid and Cytokinins in Growth Rhythms of Theobroma cacao L*. Rev. Theobroma 4:3-12.
- Alvim R, Alvim PT, Lorenzi R, Saunders PF. 1974b. *The Possible Role of Abscisic Acid and Cytokinins in Growth Rhythms of Theobroma cacao L*. Rev. Theobroma 4:3-12. Alvim R, Nair PKR (1986) *Combination of Cacao with other Plantation Crops: an Agroforestry System in Southeast Bahia, Brazil*. Agrofor. Syst. 4:3-15.

- Alvim, PT. 1958. *Stomatal Opening as a Practical Indicator of Moisture Deficiency in Cacao*. In Séptima Conferencia American Society for Horticultural Science, 117, 239-242.
- Alvim, R. and Alvim, P. de T. 1977. *Hydroperiodicity in Cocoa Tree*. In Proceedings of the 5th International Cocoa Research Conference, Ibadan, Nigeria, September 1975, 204–209.
- Amorim SMC, Valle RR. 1993. *Absorção e Resistência ao Movimento da Água no Cacaueiro*. Pesq. Agropec. Bras. 28: 907-913.
- Anas, I. 1997. *Bioteknologi Tanah*. Laboratorium Biologi Tanah. Jurusan Tanah. Fakultas Pertanian. IPB.
- Anderson JM, Ingram JSI. 1993. *Tropical Soil Biology and Fertility: A Handbook of Methods*. 2th ed. CAB, United Kingdom.
- Anderson, R. & Nelson, L.A. 1975. A Family of Models Involving Intersecting Straight Lines and Concomitant Experimental Designs useful in Evaluating Response to Fertilizer Nutrients. *Biometrics*, 31, 303-318.
- Aneani, F. & Ofori-Frimpong, K. 2013. *An Analysis of Yield Gap and Some Factors of Cocoa (Theobroma cacao) Yields in Ghana*. Sustainable Agriculture Research, 2, 117-127.
- Aneja M, Gianfagna T, Ng E. 1999. *The Roles of Abscisic Acid and Ethylene in the Abscission and Senescence of Cocoa Flowers*. *Plant Growth Regul.* 27:149-155.
- Aneja M, Gianfagna T, Ng E, Badilla I. 1992. *Carbon Dioxide and Temperature Influence Pollen Germination and Fruit Set in Cocoa*. *Hort Science* 27:1038-1040.
- Aneja M, Gianfagna T, Ng E, Badilla I. 1994. *Carbon Dioxide Treatment Partially Overcomes Self-Incompatibility in a Cacao Genotype*. *Hort Science* 29:15-17.
- Anim-Kwapong GJ. 2003. *Potential of Some Neotropical Albizia Species as Shade Trees when Replanting Cacao in Ghana*. *Agrofor. Syst.* 58:185-193.
- Appiah, M., Ofori-Frimpong, K. & Afrifa, A. 2000. *Evaluation of Fertilizer Application on some Peasant Cocoa Farms in Ghana*. *Ghana Journal of Agricultural Science*, 33, 183-190.
- Aranguren, J., Escalante, G. & Herrera, R. 1982. Nitrogen Cycle of Tropical Perennial Crops Under Shade Trees. *Plant and Soil*, 67, 259-269.
- Asner, G. P., A. R. Townsend, W. J. Riley, P. A. Matson, J. C. NeV, and C. C Cleveland. 2001. *Physical and Biogeochemical Controls Over Terrestrial Ecosystem Responses to Nitrogen Deposition*. *Biogeochemistry* 54,1-39.
- Asomaning, E., Kwakwa, R. & Hutcheon, W. 1971. *Physiological Studies on an Amazon Shade and Fertilizer Trial at the Cocoa Research Institute of Ghana*. *Ghana Journal of Agricultural Science*, 4, 47-64.

- Atanda OA. 1972. *Correlation Studies in Theobroma cacao* L. Turrialba 22:81-89.
- Auge, R.M. 2001. *Water Relations, Drought and Vesicular Arbuscular Mycorrhizal Symbiosis*. Mycorrhiza, 11: 3-42.
- Augé, R.M., K.A Schekel, and R.L. Wample. 1986. *Greater Leaf Conductance of Well-Watered VA Mycorrhizal Rose Plants is not Related to Phosphorus Nutrition*. New Phytologist 103 (1986): 107-116.
- Azcón-Aguilar, J.M. Barea, S. Gianinazzi and V. Gianinazzi-Pearson. 2009. *Mycorrhizas, Functional, Processes and Ecological Impa*. Springer-Verlag Berlin Heidelber. ISBN: 978-3-540-87977-0. 239 p.
- Bae, H., Kim, S-H., Kim, M. S., Sicher, R. C., Lary, D., Strem, M. D., Natarajan, S. and Bailey, B. A. 2008. *The Drought Response of Theobroma cacao (Cacao) and the Regulation of Genes Involved in Polyamine Biosynthesis by Drought and other Stresses*. Plant Physiology and Biochemistry 46:174–188.
- Bae, H., Sicher, R. C., Kim, M. S., Kim, S-H., Strem, M. D., Melnick, R. L. and Bailey., B. A. 2009. *The Beneficial Endophyte Trichoderma Hamatum Isolate DIS219b Promotes Growth and Delays the on Set of the Drought Response in Theobroma cacao*. Journal of Experimental Botany 60:3279–3296.
- Baker NR, Hardwick K. 1973. *Biochemical and Physiological Aspects of Leaf Development in Cocoa (Theobroma cacao)*. I. Development of chlorophyll and photosynthetic activity. New Phytol. 72:1315-1324.
- Baker NR, Hardwick K. 1974. *A Model for the Development of Photosynthetic Units in Cocoa Leaves*. Proc. 3th Int. Congress Photosynthesis, Rehovot, Israel, pp.1897-1906.
- Baker NR, Hardwick K. 1975. *Biochemical and Physiological Aspects of Leaf Development in Cocoa (Theobroma cacao)*. III. Changes in Soluble Sugar Content and Sucrose Synthesizing Capacity. New Phytol. 75:519-524.
- Baker NR, Hardwick K. 1976. *Development of Photosynthetic Apparatus in Cocoa Leaves*. Photosynthetica 10:361-366.
- Baker NR, Hardwick K, Jones P. 1975. *Biochemical and Physiological Aspects of Leaf Development in Cocoa (Theobroma cacao)*. II. Development of Chloroplast Ultrastructure and Carotenoids. New Phytol. 75:513-518.
- Baker RP, Hasenstein KH, Zavada MS. 1997. *Hormonal Changes After Compatible and Incompatible Pollination in Theobroma cacao* L. Hort Science 32:1231-1234.
- Balasimha D. 1988. *Water Relations, Growth and Other Indicators of Plant Water Stress in Cocoa Under Drought*. In: Proc. 10th Int. Cocoa Res. Conf., Santo Domingo, Dominican Republic, pp.215-217.
- Balasimha, D. and Daniel, E. V. 1988. *A Screening Method for Drought Tolerance in Cocoa*. Current Science 57: 395.

- Balasimha, D., Anil Kumar, V., Viraktamath, B. C. and Ananda, K. S. 1999. *Leaf Water Potential and Stomatal Resistance in Cocoa Hybrids and Parents*. Plantations, Recherche, Developpement 6:116–118.
- Balasimha, D., Daniel, E. V. and Bhat, P. G. 1991. *Influence of Environmental Factors on Photosynthesis in Cocoa Trees*. Agricultural and Forest Meteorology 55:15–21.
- Balasimha, D., Subramonan, N. and Chenchu Subbaiah, C. 1985. *Leaf Characteristics in Cocoa (Theobroma cacao L.) Accessions*. Café Cacao Thé 29:95–98.
- Baligar, V. C., Bunce, J. A., Machado, R. C. R. and Elson, M. K. 2008. *Photosynthetic Photon Flux Density, Carbon Dioxide Concentration, and Vapour Pressure Deficit Effects on Photosynthesis in Cacao Seedlings*. Photosynthetica 46:216–221.
- Baligar, V.C., Fageria, N.K., Machado, R.C. & Meinhardt, L. 2006. *Concentration and Uptake of P, Zn and Fe as Influenced by Soil Acidity, and Levels and Forms of N, P and Fe in Cacao*. 15th International Cocoa Research Conference. COPAL, Cost Rica.
- Bartley BGD. 1969. *Selfing of Self-Incompatible Trees*. In: Annual Report on Cacao Research. Trinidad, pp.22-23. Bartley BGD (1970) *Yield Variation in the Early Productive Years in Trials with Cacao (Theobroma cacao L.)* Euphytica 19:199-206.
- Bartley BGD. 2005. *The Genetic Diversity of Cacao and its Utilization*. CABI Publishing, Wallingford, UK.
- Bartley, B. 1970. *Yield Variation in the Early Productive Years in Trials with Cacao (Theobroma cacao L.)*. Euphytica, **19**, 199-206.
- Batista LP, Alvim R. 1981. *Efeitos da Intensidade Luminosa e do Genótipo Sobre o Crescimento em Altura do Fuste do Cacaueiro*. Rev.Theobroma 11:61-76.
- BBP2TP Surabaya. 2009. *Pengembangan Metode Formulasi Jamur Mikoriza*. http://ditjenbun.deptan.go.id/bbp2tpsur/index.php?option=com_content&view=article&id=37:p_engembangan-metode-formulasi-jamur-mikoriza&catid=6:iptek&Itemid=24. Diakses 26 April 2010.
- Beer J, Muschler R, Kass D, Somarriba E. 1998. *Shade Management in Coffee and Cacao Plantations*. Agrofor. Syst. 38:139-164.
- Beer JW. 1987. *Advantages, Disadvantages and Desirable Characteristics of Shade Trees for Coffee, Cacao and Tea*. Agrofor. Syst. 5:3-13.
- Beer, J. 1987. *Advantages, Disadvantages and Desirable Characteristics of Shade Trees for Coffee, Cacao and Tea*. Agroforestry Systems, 5, 3-13.
- Beer, J., Bonnemann, A., Chavez, W., Fassbender, H.W., Imbach, A.C. & Martel, I. 1990. *Modelling Agroforestry Systems of Cacao (Theobroma cacao) with Laurel (Cordia alliodora) or Poro (Erythrina poeppigiana) in Costa Rica*.

- Agroforestry Systems, 12, 229-249.
- Beer, J., Muschler, R., Kass, D. & Somarriba, E. 1998. *Shade Management in Coffee and Cacao Plantations*. Agroforestry Systems, 38, 139-164.
- Benizri, E. Baudoin and A. Guckert, 2001. *Root Colonization by Inoculated Plant Growth-Promoting Rhizobacteria*. Biocontrol Science and Technology, 11 2001, pp. 557–574. Berkum & Bohlool, 1980.
- Bergman JF. 1969. *The Distribution of Cacao Cultivation in Pre-Columbian America*. Ann. Assoc. Geograph. 59:85-96.
- Bertolde FZ. 2007. *Respostas Fisiológicas ao Alagamento do Substrato e Diversidade Genética Molecular de Clones de Theobroma cacao L.* Ilhéus, Universidade Estadual de Santa Cruz, M.Sc. dissertation.
- Bonaparte EENA. 1975. *Yield Gradients in Cocoa (Theobroma cacao L.) Shade and Fertilizer Experiments*. Acta Hort. 49:251-257.
- Bonaparte EENA, Ampofo, S. 1977. *The Cacao Microclimate*. In: Proc. 5th Int. Cocoa Res. Conf., Ibadan: CRIN, pp. 210-215.
- Bonaparte EENA. 1973. *An Agronomist's Assessment of Recent Research Findings and Their Implications for Cocoa Production*. In: Proc. Cocoa Econ. Res. Conf., Legon, Ghana, pp.73-85.
- Bosshart RP, von Uexkull HR. 1987. *Some Occasionally Overlooked Criteria for Assessing Fertilizer Requirements of High Yielding Cocoa*. In: Seminar on Palm Kernel Utilization and Recent Advances in Cocoa Cultivation, Sawan, Sabah Malaysia, 29p.
- Boyer J. 1970. *Influence des Régimes Hydrique, Radiatif et Thermique du Climat Sur l'activité Végétative et la Floraison de Cacaoyers Cultivés au Cameroun*. Café Cacao Thé 14:189-201.
- Boyer, J. 1973. *Cycles de la Matière Organique et des Eléments Minéraux Dans une Cacaoyère Camerounaise*. Café Cacao Thé, **18**, 3-30.
- Braudeau, J. 1969. *Le Cacaoyer*. G-P Maisonneuve et Larose, Paris.
- Bridgland, L. A. 1953. *Study of the Relationship Between Cacao Yield and Rainfall*. The Papua and New Guinea Agricultural Gazette 8:7–14.
- Brito AM, Silva GCV, Almeida CMVC, Matos PGG. 2002. *Sistemas Agroflorestais com o Cacaueiro: Uma Tentativa de Busca do Desenvolvimento Sustentável do Estado do Amazonas, Brasil*. Agrotrópica 14:61-72.
- Bruulsema, T. 2004. *Understanding the Science Behind Fertilizer Recommendations*. Better Crops, **88**, 16-19. Cabala Rosand, F.P. et al. (1966a) *Cacau Atualidades*, **3**, 6-7.
- Bryla D.R and J. M Duniway. 1997. *Effects of Mycorrhizal Infection on Drought Tolerance and Recovery in Safflower and Wheat*. Plant. Soil 197, 95–103
- Burle, L. 1961. *Le Cacaoyer*. G.-P. Maisonneuve et Larose. France, Paris.

- Byrne PN. 1972. *Cacao Shade Spacing and Fertilizing Trial in Papua and New Guinea*. In: Proc. 4th Int. Cocoa Res. Conf., St. Augustine, Trinidad and Tobago, pp.275-286.
- Cabala Rosand, F.P. et al. 1966b. *Cacau Atualidades*, 3, 8-9. Cabala Rosand, F.P. et al. (1967) *Cacau Atualidades*, 4, 52-57.
- Cacao Net. 2012. *A Global Strategy for the Conservation and Use of Cacao Genetic Resources, as the Foundation for a Sustainable Cocoa Economy*. (ed. B. Laliberté). Bioversity International, Montpellier, France.
- Cadima Zevallos A, Alvim PT. 1983. *Avaliação da Transpiração do Cacaueiro Através de Variações na Umidade do Solo*. Rev. Theobroma 12:43-48.
- Cadisch, G. & Giller, K. 1997. *Driven by Nature: Plant Litter Quality and Decomposition*. CAB International, Wallingford, UK.
- Carr, M. K. V. 2001. *The Water Relations and Irrigation Requirements of Coffee*. *Experimental Agriculture* 37:1–36. Carr, M. K. V. (2009). *The water Relations and Irrigation Requirements of Banana (Musa spp.)*. *Experimental Agriculture* 45:333–371.
- Carr, M. K. V. 2010a. *The Role of Water in the Growth of the Tea (Camellia sinensis L.) Crop: a Synthesis of Research in Eastern Africa*. 1. Plant water relations. *Experimental Agriculture* 46:327–349.
- Carr, M. K. V. 2010b. *The Role of Water in the Growth of the Tea (Camellia sinensis L.) Crop: a Synthesis of Research in Eastern Africa*. 2. Water productivity. *Experimental Agriculture* 46:351–379.
- Carr, M. K. V. and Knox, J. W. 2011. *The Water Relations and Irrigation Requirements of Sugar Cane (Saccharum officinarum L.): a Review*. *Experimental Agriculture* 47:27–51.
- Cazorla IM, Aidar T, Milde LCE. 1989. *Perfis do Lançamento Foliar, da Floração, da Bilração e de Estágios do Fruto do Cacaueiro no Estado da Bahia, no Período de 1987/1988*. In: Boletim Técnico, Ceplac/Cepec, Ilhéus, Brasil, 58p.
- Cazorla IM, Aidar T, Milde LCE. 1989. *Perfis do Lançamento Foliar, da Floração, da Bilração e de Estágios do Fruto do Cacaueiro no Estado da Bahia, no Período de 1987/1988*. In: Boletim Técnico, Ceplac/Cepec, Ilhéus, Brasil, 58p.
- Charter, C.F. 1953. *Cocoa Soils, Good and Bad*. Cyclostyled, WACRI Report.
- Cooke, G.W. (1982) *Fertilizing for Maximum Yield*. Granada, London.
- Cruickshank, A.M. (1970) *Cocoa in Grenada*. *Cocoa Growers Bulletin*, 15, 4-11.
- Cheesman, E. E. 1944. *Notes on the Nomenclature, Classification and Possible Relationships of Cacao Populations*. *Tropical Agriculture (Trinidad)* 21:144–159.
- Cocoa Research Conference, Santa Domingo, Dominican Republic*. May 1987.

159–167.

- Colas, H., Mouchet, S., Rey, H. and Kitu, W.T. 1999. *Une Approche du Comportement Hybride du Cacaoyer (Theobroma cacao L.) par des Mesures de Flux de Seve Brute: Comparaison Entre une Culture Pure et Une Culture Associee Sous Cocotier (Cocos nucifera L.)*. In Proceedings of the 12th International Cocoa Research Conference, Salvador, Bahia, Brazil, November 1996, 637–644.
- Cooke, G.W. 1982. *Fertilizing for Maximum Yield*. Granada, London.
- Corley, R. H. V. 1983. *Potential Productivity of Tropical Perennial Crops*. *Experimental Agriculture* 19:217–237.
- Costa LCB, Almeida A-AF, Valle RR. 1998. *Crescimento, Teor de Clorofila e Estrutura Anatômica em Plântulas de Theobroma cacao Submetidas a Diferentes Irradiâncias e Doses de Nitrogênio*. *Agrotropica* 10:21-30.
- Costa LCB, Almeida A-AF, Valle RR. 2001. *Gas exchange, Nitrate Assimilation and Dry-Matter Accumulation of Theobroma cacao Seedlings Submitted to Different Irradiances and Nitrogen Levels*. *J. Hort. Sci. Biotechnol.* 762:224-230.
- Couprie F. 1972. *Étude de Certains Aspects de l'ecophysiologie du Cacaoyer Liés a la Productivité en Uganda*. *Café Cacao Thé* 16:31-41.
- CPCRI. 2010. *Central Plantation Crops Research Institute, Kerala, India*. [http://cpcri.gov.in/garden % 20management-cocoa.htm](http://cpcri.gov.in/garden%20management-cocoa.htm)
- Cuatrecasas J. 1964. *Cacao and its Allies: a Taxonomic Revision of the Genus Theobroma*. *Bulletin of the United States National Museum*. Smithsonian Institution Press, Washington, 35: 379-614.
- Cunningham RK, Burridge JC. 1960. *The Growth of Cacao (Theobroma cacao) With and Without Shade*. *Ann. Bot.* 24:458-462.
- Cunningham RK, Lamb J. 1959. *A Cocoa Shade and Manurial Experiment at the West African Cocoa Research Institute, Ghana*. I. 1st Year. *J. Hort. Sci.* 34:14-22.
- Cunningham, R. & Arnold, P. 1962. *The Shade and Fertiliser Requirements of Cacao (Theobroma cacao) in Ghana*. *Journal of the Science of Food and Agriculture*, 13, 213-221.
- Da Matta FM, Loos RA, Rodrigues R, Barros RS. 2001. *Actual and Potential Photosynthetic Rates of Tropical Crop Species* *Rev. Bras. Fisiol. Veg.* 13:24-32
- DaMatta, F.M. 2004. *Ecophysiological Constraints on the Production of Shaded and Unshaded Coffee: a Review*. *Field Crops Research*, 86, 99-114.
- Damir O, P. Mladen, Š. Božidar and N. Srdan. 2011. *Cultivation of the Chroococcum for Preparation of Biofertilizers*. *African Journal of Biotechnology* Vol. 10(16), pp. 3104-3111, 18 April, 2011.

- Daswir HAS, Dja'far D.1988. *Analysis of Cacao Shaded with Coconut (Cocos nucifera) Compared with Leucaena Glauca in North Sumatra*. Bull. Perkebunan 19:99-106.
- Davamani V., A.C. Lourduraj, R.P. Yogalakshmi and M. Velmurugan. 2010. *Role of VAM in Nutrient Uptake of Crop Plants*. dalam Devarajan Thangadurai Carlos Alberto Busso Mohamed Hijri, (ed). 2010. Mycorrhizal Biotechnology. Printed in India, in Collaboration with Capital Publishing Company.
- Davies F.T., S.E. Svenson, J.C.Henderson, L. Phavaphutanon, S.A. Duray, Olal de Portugal V., C.E Meier, S.H. Bo. 1996. *Non-Nutritional Stress Acclimation of Mycorrhizal Woody Plants Exposed to Drought*. Tree Physiology 16: 985–993.
- Dawoe, E.K., Isaac, M.E. & Quashie-Sam, J. 2010. *Litterfall and Litter Nutrient Dynamics Under Cocoa Ecosystems in Low Land Humid Ghana*. Plant and Soil, **330**, 55-64.
- Daymond AJ. 2000. *An Investigation Into Physiological Parameters Underlying Yield Variation Between Different Varieties of Cocoa (Theobroma cacao L.)*. UK, University of Reading, PhD thesis.
- Daymond AJ, Hadley P, Machado RCR, Ng E. 2002a. *Canopy Characteristics of Contrasting Clones of Cacao (Theobroma cacao)*. Exp. Agric. 38:359-367.
- Daymond AJ, Hadley P, Machado RCR, Ng E. 2002b. *Genetic Variability in Partitioning to the Yield Component of Cacao (Theobroma cacao L.)*. Hort Science 37:799-801.
- Daymond, A. J. and Hadley, P. 2004. *The Effects of Temperature and Light Integral on Early Vegetative Growth and Chlorophyll Fluorescence of Four Contrasting Genotypes of Cacao (Theobroma cacao)*. Annals of Applied Biology 145:257–262.
- Daymond, A. J. and Hadley, P. 2008. *Differential Effects of Temperature on Fruit Development and Bean Quality of Contrasting Genotypes of Cacao (Theobroma cacao)*. Annals of Applied Biology 153:175–185.
- Daymond, A. J., Tricker, P. J. and Hadley, P. 2009. *Genotypic Variation in Photosynthetic and Leaf Traits in Cocoa*.
- De Geus, J.G. 1973. *Fertilizer Guide for the Tropics and Subtropics*. Centre d'Etude de l'Azote.
- de Nettancourt D. 1977. *Incompatibility in Angiosperms*. Springer-Verlag, New York.
- Delhaize, E. & Ryan, P.R. 1995. *Aluminum Toxicity and Tolerance in Plants*. Plant physiology, **107**, 315. Duguma, B., Gockowski, J. & Bakala, J. (2001) Smallholder Cacao (*Theobroma cacao* Linn.) Cultivation in Agroforestry Systems of West and Central Africa: Challenges and Opportunities. *Agroforestry Systems*, **51**, 177-188.

- Deng X, Joly RJ, Hahn DT. 1989. *Effects of Plant Water Deficit on the Daily Carbon Balance of Leaves of Cacao Seedlings*. *Physiol. Plant.* 77:407-412.
- Deng X, Joly RJ, Hahn DT. 1990. *The Influence of Plant Water Deficit on Distribution of ¹⁴C-Labeled Assimilates in Cacao Seedlings*. *Ann. Bot.* 66:211-217.
- Dewan G.I. and N..S. Subba Rao. 1979. *Seed Inoculation With Azospirillum Brasilense and Azotobacter Chroococcum and the Root Biomass of Rice (Oryza sativa L.)*. *Plant and Soil* 53: 295-- 302.
- Dewi A,I,R,. 2007. *Peran, Prospek dan Kendala dalam Pemanfaatan Endomikoriza*. Jurusan Budidaya Pertanian, Prog Studi Agronomi, Fakultas Pertanian Universitas Pajajaran, Jatinangor, Bandung,
- Dias LAS, Kageyama PY. 1997. *Temporal Stability of Multivariate Genetic Divergence in Cacao (Theobroma cacao L.) in Southern Bahia Conditions*. *Euphytica* 93:181-187.
- Dias LAS, Kageyama PY, Castro GCT. 1997. *Divergência Genética Multivariada na Preservação de Germoplasma de Cacau (Theobroma cacao L.)*. *Agrotropica* 9:29-40.
- Diczbalis, Y., Lemin, C., Richards, N. and Wicks, C. 2010. *Producing Cocoa in Northern Australia*. Australian Government, Rural Industries Research and Development Corporation Report 09/092.
- Driver J.D, Holben W.E, Rillig MC. 2005. *Characterization of Glomalgin as a Hyphal Wall Component of Arbuscular Mycorrhizal Fungi*. *Soil Biol Biochem* 37:101–106.
- Dunlop, W. R. 1925. *Rainfall Correlations in Trinidad*. *Nature (London)* 115:192–193.
- Edwards, D. F. 1973. *Pollination Studies on Upper Amazon Cocoa Clones in Ghana in Relation to the Production of Hybrid Seed*. *Journal of Horticultural Science* 48:247–259.
- Edwin, J. and Masters, W. A. 2005. *Genetic Improvement and Cocoa Yields in Ghana*. *Experimental Agriculture* 41:491–503.
- Egbe, N., Olatoye, S. & Obatolu, C. 1989. *Impact of Rate and Types of Fertilizers on Productivity and Nutrient Cycling in Tree Crop Plantation Ecosystem*. MAB Workshop Abuja. Unpublished.
- Ekanade, O. 1988. *The Nutrient Status of Soils Under Peasant Cocoa Farms of Varying Ages in South Western Nigeria*. *Biological Agriculture & Horticulture*, 5, 155-167.
- Evans, H. & Murray, D. 1953. *A Shade and Fertilizer Experiment on Young Cacao*. Report on Cacao Research, 1945-51, pp. 67-76.
- FAO. 2010. <http://faostat.fao.org/site/339/default.aspx>.

- FAOSTAT. 2015. Download Data (<http://faostat3.fao.org/download/Q/QC/E>). Production Quantity; Cocoa, Beans; All Countries; 2012. Food and Agriculture Organization of the United Nations. Accessed: 21-01-2015
- Feller, C. & Beare, M.H. 1997. *Physical Control of Soil Organic Matter Dynamics in the Tropics*. Geoderma, 79, 69-116.
- Fernandes EN, Vinha SG. 1984. *Recomposição Florística do Parque Zoobotânico do Centro de Pesquisas do Cacau*. Rev. Theobroma 14:1-25.
- Fitter, A.H. and R.K.M. Hay. 1983. *Environmental Physiology of Plants*. Academic Press Inc. New York.
- Fitts, J. & Nelson, W.L. 1956. *The Determination of Lime and Fertilizer Requirements of Soils Through Chemical Tests*. Advances in Agronomy, 8, 241-282.
- Fontes, A., Gama-Rodrigues, A., Gama-Rodrigues, E., Sales, M., Costa, M. & Machado, R. 2014. *Nutrient Stocks in Litter Fall and Litter in Cocoa Agroforests in Brazil*. Plant and Soil, **383**, 313-335.
- Fordham, R. 1972. *The Water Relations of Cacao*. In Proceedings of the IV International Cocoa Research Conference, St. Augustine, Trinidad, January 1972, 320–325.
- Foster, H. & Prabowo, N. 2002. *Overcoming the Limitations of Foliar Diagnosis in Oil Palm*. International Oil Palm Conference and Exhibition, pp. 269-281. Bali, Indonesia. Fruto e das Sementes de Sete Genótipos de *Theobroma cacao* L. Pesq. Agropec. Bras. 30:909-916.
- Galyuon IKA, McDavid CR, Lopez FB, Spence JA. 1996. *The Effect of Irradiance Level on Cocoa (Theobroma cacao L.): I. Growth and Leaf Adaptations*. Trop. Agric. 73:23-28.
- Galyuon IKA, McDavid CR, Lopez FB, Spence JA. 1996b. *The Effect of Irradiance Level on Cocoa (Theobroma cacao L.): II. Gas Exchange and Chlorophyll Fluorescence*. Trop. Agric. 73:29-33.
- Gama-Rodrigues AC, Valle RR, Rossiello ROP. 1995. *Crescimento, Trocas Gasosas e Relações Hídricas de Plântulas de Cacau em Função de Diferentes Fontes de Potássio*. Rev. Bras. Ciên. Solo 19:387-393.
- Garcia JR. 1973. *Estudo de Alguns Índices de Crescimento e Produtividade Para Seleção Juvenil em Híbridos de Cacau*. Turrialba, IICA, M.Sc. Dissertation.
- Garcia JR, Nicolella G. 1985. *Correlação Entre Algumas Medidas Dendrométricas, Origem Genética e Produção de Frutos em Cacaueiros*. Rev. Theobroma 15:113-124.
- Gattward, J.N., Almeida, A.A.F., Souza, J.O., Gomes, F.P. & Kronzucker, H.J. 2012. Sodium-Potassium Synergism in *Theobroma cacao*: stimulation of photosynthesis, water-use efficiency and mineral nutrition. Physiologia Plantarum, **146**, 350-362.

- Gerritsma, W. 1995. *Physiological Aspects of Cocoa Agronomy and its Modelling*. Wageningen University, Wageningen.
- Geypens, M. & Vandendriessche, H. 1996. *Advisory Systems for Nitrogen Fertilizer Recommendations*. Plant and Soil, 181, 31-38.
- Giller, K.E. 2001. *Nitrogen Fixation in Tropical Cropping Systems*. CABI Publishing, Wallingford.
- Giller, K.E., Cadisch, G. & Palm, C. 2002. *The North-South Divide Organic Wastes, or Resources for Nutrient Management*. Agronomie, 22, 703-709.
- Glendinning, D. 1960. *The Relationship Between Growth and Yield in Cocoa Varieties*. *Euphytica*, 9, 1-355. Glendinning, D. (1966) Further Observations on the Relationship Between Growth and Yield in Cocoa Varieties. *Euphytica*, 15, 116-127.
- Gockowski, J. & Sonwa, D. 2011. *Cocoa Intensification Scenarios and their Predicted Impact on CO₂ Emissions, Biodiversity Conservation, and Rural Livelihoods in the Guinea Rain Forest of West Africa*. Environmental Management, 48, 307-321.
- Gockowski, J., Afari-Sefa, V., Sarpong, D.B., Osei-Asare, Y.B. & Agyeman, N.F. 2013. *Improving the Productivity and Income of Ghanaian Cocoa Farmers While Maintaining Environmental Services: What Role for Certification* *International Journal of Agricultural Sustainability*, 11, 331-346.
- Godden, D.P. & Helyar, K. 1980. *An Alternative Method for Deriving Optimal Fertilizer Rates*. Review of Marketing and Agricultural Economics, 48, 83-97.
- Goenadi, D. H., Siswanto and Y. Sugiarto. 2000. *Bioactivation of Poorly Soluble Phosphate Rocks with a Phosphorus-Solubilizing Fungus*. Soil Sci. Soc. Am. J. 64:927-932.
- Goh, K. 2005. *Fertilizer Recommendation Systems for Oil Palm: Estimating the Fertilizer Rates*. Proceedings of MOSTA Best Practices Workshops-Agronomy and Crop Management. Malaysian Oil Scientists' and Technologists' Association, Kuala Lumpur.
- Gomes, A. R. S. and Kozlowski, T. T. 1988. *Stomatal Characteristics, Leaf Waxes, and Transpiration Rates of Theobroma cacao and Hevea Brasiliensis Seedlings*. *Annals of Botany* 61:425-432.
- Gong M.Q., D.P. Xu, C.L. Zhong, Y.L. Chen, B. Brundrett, B. Dell. 2000. *Mycorrhizal Fungi Diversity and Applications of Inoculation Technology*. China Forestry Publishing House, Beijing. 196p. ISBN 7-5038-2529 (Chinese & English).
- Greathouse, D. C., Laetsch, W. M. and Phinney, B. O. (1971). The shoot growth rhythm of a tropical tree, *Theobroma cacao*. *Australian Journal of Botany* 58:281-286.

- Greenwood, M. and Posnette, A. F. 1950. *The Growth Flushes of Cacao*. Journal of Horticultural Science 25:164–174.
- Groeneveld, J.H., Tschardtke, T., Moser, G. & Clough, Y. 2010. *Experimental Evidence for Stronger Cacao Yield Limitation by Pollination than by Plant Resources*. Perspectives in Plant Ecology, Evolution and Systematics, **12**, 183-191.
- Guers J.1985. *Potentialités Photosynthétiques du Cacaoyer (Theobroma cacao L.) en Fonction de l'éclairage, de la Température et du CO Ambient*. Café Cacao Thé 29:245-254.
- Gusli S. dan Nasaruddin, 2002. *Analisis Tingkat Kesuburan Tanah pada Laboratorium Lapangan Cacao Cooperative Development Centre (CCDC) Sulawesi Selatan*. Pusat Kegiatan Penelitian, Lembaga Penelitian Universitas Hasanuddin. Makassar.
- Hadley P, End M, Taylor ST, Pettipher GL. 1994. *Environmental Regulation of Vegetative and Reproductive Growth in Cocoa Grown in Controlled Glasshouse Conditions*. In: Proc. 11th Int. Cocoa Res. Conf., Yamoussoukro, Côte D'Ivoire, pp. 319-331.
- Hadley, P. and Yapp, J. H. H. 1993. *Measurement of Physiological Parameters with Respect to Yield*. In *Proceedings International Workshop on Conservation and Utilization of Cocoa Genetic Resources in the 21st Century*. The Cocoa Research Unit, University of the West Indies, Trinidad September 1992, 121–138.
- Handayanto, E., Cadisch, G. & Giller, K.E. 1995. *Manipulation of Quality and Mineralization of Tropical Legume Tree Prunings by Varying Nitrogen Supply*. Plant and Soil, **176**, 149-160.
- Hardwick K, Baker NR, Bird KJ. 1981. *Control of Chloroplast Formation and Photosynthetic Performance in Developing Cocoa (Var. Amelonado and Amazon) Leaves*. Proc. 7th Int. Cocoa Res. Conf., Douala, Cameroon, pp.135–42.
- Hardwick, K., Machado, R. C. R., Smith, J. and Veltkamp, C. J. 1988a. *Apical Bud Activity in Cocoa*. In Proceedings of the 9th International Cocoa Research Conference, Lomé, Togo, February 1984, 153–158.
- Hardwick, K., Robinson, A. W. and Collin, H. A. 1988b. *Plant Water Status and the Control of Leaf Production in Cocoa*. In Proceedings of the 9th International Cocoa Research Conference, Lomé, Togo, February 1984, 111–116.
- Hardy, F. 1958. *The Effects of Air Temperature on Growth and Production in Cacao*. Cacao 3:1–15.
- Hardy, F. 1962. Gordian, 62. Hartemink, A.E. & Donald, L.S. 2005. *Nutrient Stocks, Nutrient Cycling, and Soil Changes in Cocoa Ecosystems: A*

- Review*. Advances in Agronomy, pp. 227-253. Academic Press.
- Hartemink, A. E. 2005. *Nutrient stocks, Nutrient Cycling and Soil Changes in Cocoa Ecosystems – A Review*. Advances in Agronomy, Vol 86 (in press).
- Hartemink, A.E. & Donald, L.S. 2005. *Nutrient Stocks, Nutrient Cycling, and Soil Changes in Cocoa Ecosystems: A review*. Advances in Agronomy, pp. 227-253. Academic Press.
- Hartemink, A.E. 2006. *Soil Fertility Decline: Definitions and Assessment*. Encyclopedia of Soil Science, pp. 1618 – 1621.
- Harun RRM, Ismaiv KHJ. 1983. *The Effects of Shading Regimes on the Growth of Cocoa Seedlings (Theobroma cacao L.)*. Pertanika 6(3):15.
- Hasenstein KH, Zavada MS. 2001. *Auxin Modification of the Incompatibility Response in Theobroma cacao*. Physiol. Plant. 112:113-118.
- Hashim, G. M., C. A. A.Ciesiolka, W. A.Yusoff, A. W.Nafis, M. R. Mispan, C. W. Rose, and K. J. Coughlan. 1995. *Soil Erosion Processes in Sloping Land in the East Coast of Peninsular Malaysia*. Soil Technology, Vol 8, No 3, pp 215–233.
- Henderson J.C., F.T. Davies. 1990. *Drought Acclimation and the Morphology of Mycorrhizal Rosa Hybrida L. cv Ferdy is Independent of Leaf Elemental Content*. New Phytologist 115: 503–510.
- Hernandez, A. P., Cock, J. H. and El-Sharkawy, M. A. 1989. *The Responses of Leaf Gas Exchange and Stomatal Conductance to Air Humidity in Shade-Grown Coffee, Tea and Cacao Plants as Compared with Sunflower*. Revista Brasileira de Fisiologia Vegetal 1:155–161.
- Hindersah, R., M.R Setiawati. dan B.N Fitriatin. 2001. *Pengaruh Supernatan Suspensi Kultur Cair Azotobacter terhadap Pertumbuhan Bibit Tanaman Tomat. Laporan Penelitian*. Bandung: Lembaga Penelitian Universitas Padjadjaran.
- Hindersah, R., B.N. Fitriatin, & M.R Setiawati. 2003. *Azotobacter Application in Agricultural Soil Management*. Proceeding International Conference on Environment and Urban Management.
- Hindersah, R., M.R. Setiawati, dan B.N.Fitriatin. 2002. *Penentuan Sumber Karbon dan Nitrogen untuk Meningkatkan Kualitas Inokulan Azotobacter sebagai Pupuk Biologis pada Pembibitan Tomat*. Laporan Penelitian. Bandung: Lembaga Penelitian Universitas Padjadjaran.
- Hindersah. R. dan S. Tualar. 2004. *Potensi Rizobakteri Azotobacter dalam Meningkatkan Kesehatan Tanah*. Jurnal Natur Indonesia 5(2):127-133
- Hochmuth, G., Mylavarapu, R. & Hanlon, E. 2014. *Soil Testing for Plant-Available Nutrients—What Is It and*.
- Huan, L. K., Yee, H. C. and Wood, B. J. 1986. *Irrigation of Cocoa on Coastal Soils in Peninsular Malaysia*. In Cocoa and Coconuts: Progress and Outlook,

- Kuala Lumpur, Incorporated Society of Planters, 117–132.
- Huang, R.S., W. K. Smith and R. S. Yeast. 1983. *Influence of VA on Ggrowth, Water Relation and Leaf Oriantation in Leucaena Leucocephala (LAM) de Wit*. Jurnal Series 2814- University of Hawai, Hawai
- Hurst WJ, Tarka SM Jr, Powis TG, Valdez FJr, Hester TR. 2002. *Cacao Usage by the Earliest Maya civilization*. Nature 418:289-290.
- Husin, E. F. dan R. Marlis. 2002. *Aplikasi Cendawan Mikoriza Arbuskular sebagai Pupuk Biologi pada Pembibitan Kelapa Sawit*. Prosiding Seminar Nasional BKS PTN Wilayah Indonesia Barat, FP USU Medan.
- Hutcheon WV. 1973. *Breeding for Tolerance of Exposure and the Ability to Respond to Increased Radiation*. In: Annual Report, Cocoa Res. Inst., Ghana, pp.203-204.
- Hutcheon WV. 1976. *Photosynthesis of Cacao*. In: Annual Report, Cocoa Res. Inst., Ghana, pp.186-190.
- Hutcheon WV. 1977. *Growth and Photosynthesis of Cocoa in Relation to Environmental and Internal Factors*. In: Proc. 5th Int. Cocoa Res. Conf., Ibadan, Nigeria, pp.222-232.
- Hutcheon, W. V. 1981b. *The Cocoa Swollen Shoot Research Project at the Cocoa Research Institute, Tafo Ghana*. 1969– 78. Technical Report Volume III, Section 5 Physiology Studies, 11–35. A Joint Research Project Funded by the Overseas Development Administration, London, UK and the Ministry of Cocoa Affairs, Accra, Ghana.
- Hutcheon, W. V. 1977b. *Water Relations and Other Factors Regulating the Seasonal Periodicity and Productivity of Cocoa in Ghana*. In Proceedings of the 5th International Cocoa Research Conference, Ibadan, Nigeria, September 1975, 233–244.
- Hutcheon, W. V. (1981a). *Physiological Studies of Cocoa (Theobroma cacao) in Ghana*. PhD thesis, University of Aberdeen, UK.
- Hutcheon, W. V., Smith, R. W. and Asomaning, E. J. A. 1973. *Effect of Irrigation on the Yield and Physiological Behaviour of Mature Amelonado Cocoa in Ghana*. Tropical Agriculture (Trinidad) 50(4):261–272. ICCO (2010). Quarterly Bulletin of Cocoa Statistics XXXVI No 2 (Cocoa Year 2009/10). International Cocoa Organisation.
- International Cocoa Organization (ICCO). 2007. *Annual report 2006/2007*.
- Isaac, M., Timmer, V. & Quashie-Sam, S. 2007. *Shade Tree Effects in an 8-year-old Cocoa Agroforestry System: Biomass and Nutrient diagnosis of Theobroma cacao by Vector Analysis*. Nutrient Cycling in Agroecosystems, 78, 155-165.
- Iserentant R. 1976. *Contribution à l'étude de la Croissance du Cacaoyer*. Bull. Soc. Bot. Belg. 109:55-59.

- Iwaro AD, Singh V, Barath S, Jugmohan N. 2001. *Germplasm Evaluation at the International Cocoa Genebank*. Trinidad for Resistance to Phytophthora pod rot. In: Annual Report 2000 of the Cocoa Research Unit., University of the West Indies, Trinidad, pp.34-40.
- Jadin, P. & Snoeck, J. 1985. *La Méthode du Diagnostic Sol Pour Calculer Les Besoins en Engrais des Cacaoyers*. Café Cacao Thé, **29**, 255-266.
- Jadin, P. & Vaast, P. 1990. *Estimation des Besoins en Engrais des Sols à Vocation Cacaoyère dans le Littimé (Togo)*. Café Cacao Thé, **34**, 179-188.
- Jadin, P. 1972. *Etude de la Fertilization Minérale des Cacaoyers en Cote D'Ivoire a Partir du Diagnostic Sol*. Café Cacao Thé, **16**, 204-218.
- Jadin, P. 1975. *L'utilisation du Diagnostic Sol Pour l'estimation des Besoins en Engrais des Cacaoyères Ivoiriennes*. Café Cacao Thé, **19**, 203-220.
- Jadin, P. and Jacquemart, J-P. 1978. *Effet de l'irrigation sur la Précocité des Jeunes Cacaoyers*. Café Cacao Thé **22**:31–35. Jadin, P. and Snoeck, J. 1981. Evolution du Stock d'eau Sous une Cacaoyere—Relation Avec le Climat. In Proceedings of the 8th International Cocoa Research Conference, Cartagena, Colombia, October 1981, 127–135.
- Jadin, P., Chauchard, A. and Bois, J. F. 1976. *Alimentation Hydrique des Jeunes Cacaoyers Influence de l'irrigation*. Café Cacao Thé **20**:173–199.
- Janssen, B.H. 1974. *A Double Pot Technique for Rapid Soil Testing*. Agricultural University Wageningen, Wageningen.
- Janssen, B.H. 1998. *Efficient Use of Nutrients: an Art of Balancing*. Field Crops Research, **56**, 197-201. Janssen, B.H., Lathwell, D.J. & Wolf, J. (1987) Modeling Long-Term Crop Response to Fertilizer Phosphorus. II. Comparison with Field Results. *Agronomy Journal*, **79**, 452-458.
- Janssen, B.H., Guiking, F.C.T., van der Eijk, D., Smaling, E.M.A., Wolf, J. & van Reuler, H. 1990. *A System for Quantitative Evaluation of the Fertility of Tropical Soils (QUEFTS)*. *Geoderma*, **46**, 299-318.
- Johnston, A. 2005. *Base Saturation and Basic Cation Saturation Ratios—How Do They Fit in Northern Great Plains Soil Analysis*. News & Views. PPI & PPIC, Canada.
- Joly RJ. 1988. *Physiological Adaptations for Maintaining Photosynthesis Under Water Stress in Cacao*. In: Proc. 10th Int. Cocoa Res. Conf., Santo Domingo, Dominican.
- Joly, R. J. and Hahn, D. T. 1989. *Net CO₂ Assimilation of Cacao Seedlings During Periods of Plant Water Deficit*. *Photosynthesis Research* **21**:151–159.
- Jones Jr, J.B. 2012. *Plant Nutrition and Soil Fertility Manual*. CRC press, Boca Raton, FL.
- Juarez, B., M.V. Martinez-Toledo, J. Gonzalez-Lopez., 2005. *Growth of*

- Azotobacter Chroococcum* in Chemically Defined Media Containing *p*-Hydroxybenzoic Acid and Protocatechuic Acid. *Chemosphere* 59. 2005. 1361–1365.
- Kader M.A., M.H. Mian and M.S. Hoque. 2002. *Effect of Azotobacter Inoculant on the Yield and Nitrogen Uptake by Wheat*, *J. Boil. Sci.* 4: 259-261, <http://eprints.kfupm.edu.sa/93699/1/936991>. Laegreid et al. 1999.
- Kähkölä, A.-K., Nygren, P., Leblanc, H.A., Pennanen, T. & Pietikäinen, J. 2012. *Leaf and Root Litter of a Legume Tree as Nitrogen Sources for Cacaos with Different Root Colonisation by Arbuscular Mycorrhizae*. *Nutrient Cycling in Agroecosystems*, **92**, 51-65.
- Kamprath, E.J. 1970. *Exchangeable Aluminum as a Criterion for Liming Leached Mineral Soils*. *Soil Science Society of America Journal*, 34, 252-254.
- Khan MN, Patterson GR, Matlick BR. 1988. *Effect of Supplemental Water Supplied Through Drip Irrigation on Cocoa Yield at Lunningbird, Hershey, Ltd. Belize, C.A.* In: Proc. 10th Int. Cocoa Res. Conf., Santo Domingo, Dominican Republic, pp.185-191.
- Köhler, M., Schwendenmann, L. and Hölscher, D. 2010. Throughfall Reduction in a Cacao Agroforest: Tree Water Use and Soil Water Budgeting. *Agricultural and Forest Meteorology* 150:1079–1089.
- Kummerow J, Kummerow A, Alvim PT. 1981. *Root Biomass in a Mature Cacao (Theobroma cacao L.) Plantation*. *Rev. Theobroma* 11:77-86.
- Kummerow J, Kummerow M, Silva WS. 1982. *Fine-Root Growth Dynamics in Cacao (T. cacao)*. *Plant Soil* 65:193-201.
- Kummerow., J., Kummerow., A. and Alvim, P. de T. 1981. *Root Biomass in a Mature Cacao (Theobroma cacao L.) Plantation*. *Revista Theobroma* 12:77–85.
- Lachenaud P, Mooleedhar V, Couturier C. 1997. *Les Cacaoyers Spontanés de Guyane*. *Nouvelles Prospections*. *Plant. Rech. Dévelop.* 4:25-30.
- Läderach, P., Martinez-Valle, A., Schroth, G. & Castro, N. 2013.. *Climatic Change*, **119**, 841-854. *Predicting the Future Climatic Suitability for Cocoa Farming of the World's Leading Producer Countries, Ghana and Côte d'Ivoire*
- Läderach, P., Martinez-Valle, A., Schroth, G. & Castro, N. 2013. *Predicting the Future Climatic Suitability for.*
- Lal, R. 1986. *Conversion of Tropical Rainforest: Agronomic Potential and Ecological Consequences*. *Adv. Agron.* 39, 173–264. Lal, 1986.
- Lanaud C, Sounigo O, Amefia YK, Paulin D, Lachenaud P, Clement D. 1987. *Nouvelles Données sur le Fonctionnement du Système D'incompatibilité du Cacaoyer et ses Conséquences Pour la Sélection*. *Café Cacao Thé*

31:267-277.

- Ledgard, S.J. & Giller, K.E. 1995. *Atmospheric N₂-Fixation as an Alternative Nitrogen Source*. Nitrogen Fertilization in the Environment (ed. P. Bacon), pp. 443-486. Marcel Dekker, New York.
- Lee DW, Brammeier S, Smith AP. 1987. *The Selective Advantages of Anthocyanins in Developing Leaves of Mango and Cacao*. Biotropica 19:40-49.
- Lee, G. R. 1975. *Irrigated Upper Amazon Cacao in the Lower Shire Valley of Malawi*. II-A Water Rates Trial. Tropical Agriculture (Trinidad) 52:179–182.
- Leite JO, Valle RR. 2000. *Relações Entre a Precipitação, o Lençol Freático e a Produção de Cacao na Bahia*.
- Leite RMO, Alvim R, Alvim PT. 1980. *Ação do Vento e da Radiação Solar na Ruptura do Pulvino Foliar do Cacaueiro*. Rev. Theobroma 104:235-251.
- Liaku D.I. 2009. *Mikoriza Meningkatkan Agregat Tanah Dan Ketersediaan P*. <http://mawarhitamsempurna.blogspot.com/2009/10/mikoriza-meningkatkan-agregat-tanahdan.html>. Diakses tanggal 30-5- 2010.
- Ling, A. 1989. *Cocoa Nutrition and Manuring in Malaysia*. Malaysian Cocoa Board Workshop on Cocoa Agricultural Research, pp. 131-142. Malaysian Cocoa Growers Council, Kuala Lumpur. Ling, A. (1990) *Cocoa Nutrition and Manuring in Malaysia*. Planter, Kuala Lumpur, **66**, 302-312.
- Ling, A. 1990. *Cocoa Nutrition and Manuring in Malaysia*. Planter, Kuala Lumpur. 66, 302-312.
- Ling, A. H. 1986. *Litter Production and Nutrient Cycling in a Mature Cocoa Plantation on Inland Soils of Peninsular Malaysia*. In "Proc. Int. Conf. Cocoa and Coconuts, Kuala Lumpur" (E. Pushparajah and C.P. Soon, Eds.), pp. 451–465.
- Liyanage LVK. 1985. *Rationale for Intercropping*. Coconut Bull. 2:31-35.
- Lobão DE, Setenta WC, Lobão ESP, Curvelo K, Valle RR. 2007. *Cacau Cabruca: Sistema Agrossilvicultural Tropical*. In: Valle RR (ed), *Ciência, Tecnologia e Manejo do Cacaueiro*, pp.290-323, Gráfica e Editora Vital Ltda, Ilhéus.
- Lockwood, G. 1976. *A Comparison of the Growth and Yield During a 20 Year Period of Amelonado and Upper Amazon hybrid Cocoa in Ghana*. Euphytica, **25**, 647-658.
- Lockwood, G. and Boamah Adomako, K. 2011. A review of cocoa clone trials in Ghana. Experimental Agriculture (in preparation).
- Lockwood, G. and Boamah Adomako, K. 2011. *A review of Cocoa Clone Trials in Ghana*. Experimental Agriculture (in preparation).
- Lockwood, G. and Pang, J. T. Y. 1996. *Yields of Cocoa Clones in Response to*

- Planting Density in Malaysia*. Experimental Agriculture 32:41–47.
- Loué, A. 1961. *Étude des Carences et des Déficiences Minérales sur le Cacaoyer*. IFCC Bulletin. Institut Français du Café et du Cacao, Paris.
- Loué, A., Verlière, G. & Lay, L. 1960. *Recherches Sur la Nutrition Minérale et La Fertilisation du Cacaoyer et étude des Sols à Cacaoyers de Côte d'Ivoire*. VIII. Inter-amer. Cacao Conf., pp. 334-344. Trin. Tob.
- Lucas, R. & Davis, J. 1961. *Relationships Between pH Values of Organic Soils and Availabilities of 12 Plant Nutrients*. Soil Science, **92**, 177-182. Maliphant, G. & Walmsley, D. 1961. *The Use of Fertilizers in Cocoa Cultivation in The Western Hemisphere*. Rep. Cocoa Conf., pp. 115-118. London.
- Lugtenberg B.J.J., L. Dekkers. G. Bloemberg. 2001. *Molecular Determinants of Rhizosphere Colonization by Pseudomonas*. Annu Rev Phytopathol 39:461–490.
- Machado RCR . 1986. *Carbohydrate as A Factor Controlling Leaf Development in Cocoa*. UK, University of Liverpool. PhD thesis.
- Machado RCR, Hardwick K. 1987. *Dynamics and Histology of Individual Leaf and Whole Flush Development Yield Clues on The Control of The Cocoa Flush cycle*. In: Proc. 10th Int. Cocoa Res. Conf., Santo Domingo, Dominican Republic, pp.143-149.
- Machado RCR, Alvim PT. 1981. *Effects of Soil Water Deficit on The Flushing, Flowering and Water Status of Cacao Trees*. Rev. Theobroma 11:183-191.
- Machado RCR, Hardwick K. 1988. *Does Carbohydrate Availability Control Flush Growth in Cocoa?* In: Proc.10th Int. Cocoa Res. Conf., Santo Domingo, Dominican Republic, pp.151-157.
- Maidment, W.T.O. 1928. *Correlation Between Rainfall and Cacao Yields in The Gold Coast with Special Reference to Effect of April Rains on The Following Cacao Crop*. Department of Agriculture Gold Coast Year–Book, 1927, Bulletin 13:83–91.
- Maliphant, G. & Walmsley, D. 1961. *The Use of Fertilizers in Cocoa Cultivation in The Western Hemisphere*. Rep. Cocoa Conf., pp. 115-118. London.
- Mariano AH, Monteiro WR . 1982. *Melhoramento Genético do Cacau – avaliação Preliminar de Cultivares, Ensaio 30*. In: Informe Técnico, Comissão Executiva do Plano da Lavoura Cacaueira, Centro de Pesquisas do Cacau, Ilhéus, Brazil, pp.5-7.
- Marita JM, Nienhuis J, Pires JL, Aitken WM. 2001. *Analysis of Genetic Diversity in Theobroma cacao with Emphasis on Witches' Broom Disease Resistance*. Crop Sci. 41:1305-1316.
- Maro, G., Mrema, J., Msanya, B., Janssen, B. & Teri, J. 2014. *Developing A Coffee Yield Prediction and Integrated Soil Fertility Management Recommendation Model for Northern Tanzania*. International Journal of Plant & Soil Science, **3**, 380-396.

- Marschner. H. 1995. *Mineral Nutrition of Higher Plants*. 2 Edition. Academic Press. London. UK. University of Liverpool.
- Martin S. 2006. *Cacao in Ancient Maya Religion: First Fruit from The Maize Tree and Other Tales from The Underworld*. In: McNeil CL (ed), *Chocolate in Mesoamerica: A cultural History of Cacao*, pp. 154-183. University Press of Florida, Gainesville.
- Martins DV. 1976. *Variação Sazonal de Alguns Elementos Minerais na Seiva Xilemática do Cacaueiro (Theobroma cacao L.)*. Salvador, Universidade Federal da Bahia, M.Sc. dissertation.
- McCreary, C. W. R., McDonald, J. A., Muldoon, V. I. and Hardy, F. 1943. *The Root System of Cacao: Results of Some Preliminary Investigations in Trinidad*. *Tropical Agriculture (Trinidad)* 20:207–220.
- McKelvie, A. D. 1956. *Cherelle Wilt of Cacao*. I. Pod development and its relation to wilt. *Journal of Experimental Botany* 7:252–263.
- Medeiros ZMD, Silva WS, Vogel M. 1987. *Atividades das Raízes Finas de Cacaueiros em Função da Hidroperiodicidade*. *Rev. Theobroma* 17:233-241.
- Merkel U, Müller MW, Serrano-Minar P, Biehl B. 1994. *Light Intensity Influence on The Characteristics of The Photosynthetic Apparatus from Cocoa Tree (Theobroma cacao L.) during Leaf Development*. In: Proc.11th Int. Cocoa Res. Conf., Yamoussoukro, Côte D'Ivoire, pp.645-653.
- Mielke MS, Almeida A-AF, Gomes FP. 2005. *Photosynthetic Traits of Five Neotropical Rainforest Tree Species: Interactions Between Light Response Curves and Leaf-to-air Vapour Pressure Deficit*. *Braz. Arch. Biol. Technol.* 48:815-824.
- Miranda RAC, Milde LCE, Bichara AL, Cornell S. 1994. *Daily Characterisation of Air Temperature and Relative Humidity Profiles in A Cocoa Plantation*. *Pesq. Agropec. Bras.* 29:345-353.
- Mirzakhani M, M.R. Ardakani, A. Aeene Band, F. Rejali and A.H. Shirani Rad. 2009. *Response of Spring Safflower to Co-Inoculation with Azotobacter chroococum and Glomus intraradices Under Different Levels of Nitrogen and Phosphorus*. *American Journal of Agricultural and Biological Sciences* 4 (3): 255-261
- Miyaji K, Silva WS, Alvim PT. 1990. *Longevity and Productivity of Leaves of Theobroma cacao L. In Relation to Their Position within The Canopy Under Different Shading*. In: Abstracts of the V International Congress of Ecology, Yokohama, pp.273.
- Miyaji K-I, Silva WS, Alvim PT. 1997a. *Productivity of Leaves of A Tropical Tree, Theobroma cacao, Grown Under Shading, In Relation to Leaf Age and Light Conditions within The Canopy*. *New Phytol.* 137:463-472.
- Miyaji K-I, Silva WS, Alvim PT. 1997b. *Longevity of Leaves of A Tropical Tree,*

- Theobroma cacao*, Grown Under Shading, In Relation to Position within The Canopy and Time of Emergence. *New Phytol.* 135:445- 454.
- Moody, J. & Quinn, P. 1996. *Atmospheric Deposition of Nutrients to The North Atlantic Basin*. Nitrogen Cycling in the North Atlantic Ocean and its Watersheds, pp. 27-73. Springer Netherlands.
- Morton J.B, G.L Benny. 2003. *Two New Families of Glomales, Archaeosporaceae and Paraglomaceae, with Two New Genera Archaeospora and Paraglomus, Based On Concordant Molecular and Morphological Characters*. *Mycologia* 93:181–195
- Moser, G., Leuschner, C., Hertel, D., Hölscher, D., Köhler, M., Leitner, D., Michalzik, B., Prihastanti, E., Tjitrosemito, S. and Schwendenmann, L. 2010. *Response of Cocoa Trees (Theobroma cacao) to a 13-month Desiccation Period in Sulawesi, Indonesia*. *Agroforestry Systems* 79:171–187.
- Mosse, S. 1981. *Vesicular Arbuscular Mycorrhizae for Tropical Agriculture*. *Res. Bull.*
- Mossu, G. 1995. *3 The Plant and Its Environment*. Cocoa (ed. CTA). Macmillan, London.
- Motamayor J.C, A.M. Risterucci, P.A Lopez, C.F Ortiz, A .Moreno, .C. Lanaud. 2002. *Cacao domestication*. I. The origin of the cacao cultivated by the Mayas. *Heredity* 89:380-386
- Motamayor JC. 2001. *Etude de la Diversité Génétique et de la Domestication des Cacaoyers du Groupe Criollo (Theobroma cacao L.) à l'aide de Marqueurs Moléculaires*. Paris, Université Paris XI, PhD thesis.
- Motamayor JC, Risterucci AM, Lopez PA, Ortiz CF, Moreno A, Lanaud C. 2002. *Cacao Domestication*. I. The Origin of The Cacao Cultivated by The Mayas. *Heredity* 89:380-386.
- Motamayor, J. C., Lachenaud, P., de Silva e Mota, J. W., Loor, R., Kuhn, D. N., Brown, J. S. and Schnell, R. J. 2008. *Geographic and Genetic Population Differentiation of the Amazonian Chocolate Tree (Theobroma cacao L.)*. *PLoS ONE* 3(10): e3311.doi:10.1371/journal.pone.0003311.
- Müller MW, Serrano-Minar P, Biehl B. 1992. *Photosynthetic Characteristics During Development of Leaves from Theobroma cacao L.* *Physiol. Plant.* 85:3:593-599.
- Müller MW, Gama-Rodrigues AC. 2007. *Sistemas Agroflorestais com Cacaueiro*. In: Valle RR (ed), *Ciência, Tecnologia e Manejo do Cacaueiro*, pp.246-271. Gráfica e Editora Vital Ltda, Ilhéus.
- Muñoz F, Beer J. 2001. *Fine Root Dynamics of Shaded Cacao Plantations in Costa Rica*. *Agrofor. Syst.* 51:119-130.

- Munoz, F., and J. Beer. 2001. *Fine Root Dynamics of Shaded Cacao Plantations in Costa Rica*. *Agrofor. Syst.* 51, 119–130
- Murray DB, Nichols R. 1966. *Light, Shade and Growth in Some Tropical Plants*. In: Bainbridge R, Evans GC, Rackham O (eds), *Light as an Ecological Factor*, pp.249-263, Blackwell, Oxford.
- Murray, D. 1975. *Shade and Nutrition*. *Cocoa* (ed. G.A.R. Wood), pp. 105-124. Longman, London.
- Murray, D. B. 1961. *Soil Moisture and Cropping Cycles in Cacao*. In *A Report on Cacao Research 1959–1960*. Imperial College of Tropical Agriculture, Trinidad, St. Augustine, 18–22.
- Muthukumar.T. and K. Udaiyan. 2000. Arbuscular mycorrhizas of plants growing in the Western Ghats region- Southern India.
- Nasaruddin and Ridwan I. 2017. *Effectivity of Azotobacter chroococcum and Arbuscular Mycorrhiza Fungi on Physiological Characteristics and Growth of Cocoa Seedlings*. International Conference on Food Security and Sustainable Agriculture in the Tropics. Oct. 24-25th 2017. Makassar South Sulawesi, Indonesia.
- Nasaruddin, 2010b. *Kakao, Budidaya dan Beberapa Aspek Fisiologisnya*. Jakarta: Jurusan Budidaya Pertanian dan Yayasan Fore Indonesia .
- Nasaruddin. 2012. *Kakao, Pengenalan klon, Rehabilitasi, Peremajaan dan Intensifikasi*. Makassar: Masagena Press.
- Nasaruddin. 2012b. *Efektifitas Pemanfaatan Azotobacter chroococcum dan Jamur Mikoriza Arbuskula (Glomus) terhadap Ketersediaan Hara dan Pertumbuhan Tanaman Kakao (Theobroma cacao L.)*. Desertasi Pascasarjana Universitas. Universitas Hasanuddin. Makassar.
- Nasaruddin. 2013. *Pengaruh Pengemburan Tanah dan Pemberian Mulsa Daun Kakao Terhadap Perkembangan Akar Halus pada Kebun Kakao PTPN XIV Awaysa-Halmahera tengah*. PTPN XIV. Makassar
- Nasaruddin. 2003. *Pengaruh Jenis Naungan dan Intensitas Cahaya terhadap Beberapa Aktifitas Fisiologi dan Pertumbuhan Tanaman Kakao umur 1 Tahun*. Jurusan Budidaya Tanaman Fakultas Pertanian dan Kehutanan. Universitas Hasanuddin Makassar
- Nasaruddin. 2010c. *Nutrisi Tanaman*. Jurusan Budidaya Pertanian, Prog Studi Agroteknologi. Fakultas Pertanian Unhas. Makassar.
- Naswin. 2003. *Pemanfaatan Urine Sapi Yang Difermentasi sebagai Nutrisi Tanaman*. http://tumoutou.net/702_07134/naswir.htm. 28 Februari 2009
- Neeteson, J. & Wadman, W. 1987. *Assessment of Economically Optimum Application Rates of Fertilizer N on The Basis of Response Curves*. *Fertilizer research*, **12**, 37-52.
- Nelson, P., Webb, M., Berthelsen, S., Curry, G., Yinil, D., Fidelis, C., Fisher, M. &

- Oberthür, T. 2011. *Nutritional Status of Cocoa in Papua New Guinea*. Better Crops, 95.
- Ng E. 1982. *Potential Cacao Photosynthetic Productivity*. In: Proc. 8th Int. Cacao Res. Conf., Cartagena, Colombia, pp.235-244.
- Niemenak, N., Cilas, C., Rohsius, C., Bleiholder, H., Meier, U. and Lieberei, R. 2009. *Phenological Growth Stages of Cacao Plants (Theobroma sp.): Codification and Description According to the BBCH scale*. Annals of Applied Biology 156:13–24.
- Nyombi, K., van Asten, P.J.A., Corbeels, M., Taulya, G., Leffelaar, P.A. & Giller, K.E. 2010. *Mineral Fertilizer Response and Nutrient Use Efficiencies of East African Highland Banana (Musa spp., AAA-EAHB, cv. Kisansa)*. Field Crops Research, **117**, 38-50.
- Obiri, B. D., Bright, G. A., McDonald, M. A., Anglaaere, L. C. N. and Cobbina, J. 2007. *Financial Analysis of Shaded Cocoa in Ghana*. Agroforestry Systems 71:139–149.
- Ofori-Frimpong, K., Afrifa, A. & Appiah, M. 2002. *Growth and Nutrient Uptake of Some Cocoa Varieties Grown in Contrasting Soils*. Ghana Journal of Agricultural Science, **35**, 41-48.
- Ofori-Frimpong, K., Asase, A., Mason, J. & Danku, L. 2007. *Shaded Versus Unshaded Cocoa: Implications on Litter Fall, Decomposition, Soil Fertility and Cocoa Pod Development*. Symposium on multistrata agroforestry systems with perennial crops, CATIE Turrialba, pp. 17-21. Costa Rica.
- Okali DUU, Owusu JK. 1975. *Growth Analysis and Photosynthetic Rates of Cocoa (Theobroma cacao L.) Seedlings in Relation to Varying Shade and Nutrient Regimes*. Ghana J. Agric. Sci. 8:51-67.
- Olson, R., Frank, K., Grabouski, P. & Rehm, G. 1982. *Economic and Agronomic Impacts of Varied Philosophies of Soil Testing*. Agronomy Journal, 74, 492-499.
- Orchard JE. 1978. *Efeito do K na transpiração, na resistência difusiva de folha e crescimento em plântulas de Theobroma cacao L.* In: Informe técnico, Cepec/Ceplac, Ilhéus, Brasil, pp.61-64.
- Orchard JE, Collin HA, Hardwich K. 1980. *Biochemical and Physiological Aspects of Leaf Development in Cocoa (Theobroma cacao)*. IV. Changes in Growth Inhibitors. Plant Sci. Lett. 18:299-305.
- Orchard JE, Collin HA, Hardwich K. 1981. *Biochemical and Physiological Aspects of Leaf Development in Cocoa (Theobroma cacao)*. V. Changes in Auxins and Cytokinins. Café Cacao Thé 25:25-28.
- Orchard JE, Saltos MR. 1988. *The Growth and Water Status of Cacao During its First Year of Establishment Under Different Methods of Soil Water Management*. In: Proc. 10th Int. Cocoa Res. Conf., Santo Domingo, Dominican Republic, pp.193-198.

- Orchard, J. E. 1985. *The Effect of The Dry Season on The Water Status of T. cacao in Ecuador*. In Proceedings of the 9th International Cocoa Research Conference, Lomé, Togo, February 1984, 103–109.
- Osman, H., Nasarudin, R. & Lee, S.L. 2004. *Extracts of Cocoa (Theobroma cacao L.) Leaves and Their Antioxidation Potential*. Food Chemistry, 86, 41-46.
- Owusu JK. 1978. *Light Requirements of Cocoa: A Review*. In: Proc. Int. Conf. Cocoa and Coconuts, Kuala Lumpur, Malaysia, pp.112-121.
- Owusu, K. and Waylen, P. 2009. *Trends in Spatial-temporal Variability in Annual Rainfall in Ghana (1951–2000)*. Weather 64:115–120.
- Padi B, Owusu JK. 1998. *Towards an Integrated Pest Management for Sustainable Cocoa production in Ghana*. Paper from workshop held in Panama, 3/30-4/2. Smithsonian Institution. Washington, D.C.
- Pang, J. T. Y. 2006. *Yield Efficiency in Progeny Trials with Cocoa*. Experimental Agriculture 42:289–299.
- Parent, L.E. & Dafir, M. 1992. *A Theoretical Concept of Compositional Nutrient Diagnosis*. Journal of the American Society for Horticultural Science, 117, 239-242.
- Pattimahu. D.V. 2004. *Restorasi Lahan Kritis Pasca Tambang Sesuai Kaidah Ekologi*. Makalah Mata Kuliah Falsafah Sains. Sekolah Pasca Sarjana. IPB. Bogor
- Posner, J.L. & Crawford, E.W. 1992. *Improving Fertilizer Recommendations for Subsistence farmers in West Africa: The Use of Agro-economic Analysis of On-farm Trials*. Fertilizer research, 32, 333-342. Pushparajah, E. 1994. *Leaf Analysis and Soil Testing for Plantation Tree Crops*. Food & Fertilizer Technology Center, Taipei City.
- Pound FJ. 1932. *Studies of Fruitfulness in Cacao*. 2. Evidence for partial sterility. In: First Annual Report on Cacao Research. Trinidad, pp. 26-28.
- Premachandra, G. S. and Joly, R. J. 1994. *Leaf Water Relations, Net CO₂ Assimilation, Stomatal Conductance and Osmotic Concentration as Affected by Water Deficit in Cacao Seedlings*. In Proceedings of the International Cocoa Conference: Challenges in the 90s. Kuala Lumpur, Malaysia, September 1991, 351–359.
- Purseglove, J. W. 1968. *Tropical Crops: Dicotyledons*. London: Longman.
- Rabbinge, R. 1993. *The ecological background of food production*. Crop protection and sustainable agriculture, Ciba Foundation Symposium 177, pp. 2-29. John Wiley, Chichester.
- Rada, F., Jaimez, R. E., Garcia-Núñez, C., Azócar, A. and Ramirez, M. E. 2005. *Water Relations and Gas Exchange in Theobroma cacao var. Guasare Under Periods of Water Deficit*. Revista de la Facultad de Agronomía

22:112–120.

- Radersma, S. and Ridder, N. De. 1996. *Computed evapotranspiration of annual and perennial crops at different temporal and spatial scales using published parameter values*. *Agricultural Water Management* 31:17–34.
- Raja Harun, R. M. and Hardwick, K. 1988. *The Effect of Different Temperature and Vapour Pressure Deficits on Photosynthesis and Transpiration of Cocoa Leaves*. In *Proceedings of the 10th International Cocoa Conference*, Santo Domingo, Dominican Republic, May 1987, 211–214.
- Raja Harun RM, Hardwick K. 1988a. *The Effects of Prolonged Exposure to Different Light Intensities on The Photosynthesis of Cocoa Leaves*. In: *Proc. 10th Int. Cocoa Res. Conf.*, Santo Domingo, Dominican Republic, pp.205-209.
- Raja Harun RM, Hardwick K. 1988b. *The Effect of Different Temperatures and Water Vapour Pressure Deficits on Photosynthesis and Transpiration of Cocoa Leaves*. In: *Proc. 10th Int. Cocoa Res. Conf.*, Santo Domingo, Dominican Republic, pp.211-214.
- Razi, M. I., Halim, A. H., Kamariah, D. and Noh, M. J. 1992. *Growth, Plant Water Relations and Photosynthesis Rates of Young Theobroma cacao as Influenced by Water Stress*. *Pertanika* 15:93–98.
- Rehem BC. 2006. *Respostas Fisiológicas de Clones de Theobroma cacao L. ao alagamento do Substrato*. Ilhéus, Universidade Estadual de Santa Cruz, M.Sc. dissertation.
- Rodriguez RM, Carvajal JF, Machicado M, Jimenez M. 1963. *Nutritional Requirements of The Cocoa Plant During a Yearly Cycle*. *Cacao* 8:1-7.
- Rosenberg DE, Marcotte, TP. 2005. *Land-use System Modeling and Analysis of Shaded Cacao Production in Belize*. *Agrofor. Syst.* 64:117-129.
- Ruf, F. & Bini, S. 2012. *Cocoa and Fertilizers in West-Africa*. IDH.
- Ruf, F. 1995. *From Forest Rents to Tree-capital: Basic “laws” of Cocoa Supply*. In *Cocoa Cycles: The Economies of Cocoa*
- Ruf, F., Kla, A.G., Dja, K. & Kiendré, J. 2015. *Chicken Manure in The Cocoa Plantations of Côte d'Ivoire* (http://inter-reseaux.org/ressources-thematiques/article/innovation-paysanne-la-fiente-de?lang=fr&var_mode=calcul). *Inter-réseaux*. Accessed: May 2015
- Rufino, M.C., Tittonell, P., van Wijk, M.T., Castellanos-Navarrete, A., Delve, R.J., de Ridder, N. & Giller, K.E. 2007. *Manure as A Key Resource within Smallholder Farming Systems: Analysing Narm-scale nutrient Cycling Efficiencies with the NUANCES Framework*. *Livestock Science*, **112**, 273-287.
- Sale PJM. 1968. *Flushing and Leaf Growth of Cacao Under Controlled*

- Temperature Conditions*. J. Hort. Sci. 43:475- 489.
- Sale PJM. 1969. *Flowering of Cacao Under Controlled Temperature Conditions*. J. Hort. Sci. 44: 163-173.
- Sale PJM. 1970a. *Growth, Flowering, and Fruiting of Cacao Under Controlled Soil Moisture Conditions*. J. Hort. Sci. 45:99-118.
- Sale, P. J. M. 1970. *Growth and Flowering of Cacao Under Controlled Atmospheric Relative Humidities*. Journal of Horticultural Science 45:129–132.
- Sanchez, P. A. 1995. *Science in agroforestry*. Agrofor. Syst. 30, 5–55.
- Sanchez, P.A. 1976. *Properties and Management of Soils in The Tropics*. New York: John Willey and Sons. pp. 618.
- Santana MBM, Igue K. 1979. *Composição química das folhas do cacauzeiro em função da idade e da época do ano*. Rev. Theobroma 9:63-76.
- Santana, M. & Cabala-Rosand, P. 1982. *Dynamics of Nitrogen in A Shaded Cacao Plantation*. Plant and Soil, 67, 271-281.
- Sasli, I. 2004. *Peranan Mikoriza Vesikula Arbuskula (MVA) dalam Peningkatan Resistensi Tanaman terhadap Cekaman Kekeringan*. Makalah pribadi Pengantar ke Falsafah Sains (PPS702). Sekolah Pasca Sarjana / S3. Institut Pertanian Bogor. Mei 2004.
- Sattari, S., Van Ittersum, M., Bouwman, A., Smit, A. & Janssen, B. 2014. *Crop Yield Response to Soil Fertility and N, P, K Inputs in Different Environments: Testing and Improving The QUEFTS Model*. Field Crops Research, 157, 35-46.
- Sattari, S.Z., Bouwman, A.F., Giller, K.E. & van Ittersum, M.K. 2012. *Residual Soil Phosphorus as The Missing Piece in The Global Phosphorus Crisis Puzzle*. Proceedings of the National Academy of Sciences, 109, 6348-6353.
- Sena Gomes AR and Kozlowski TT. 1986. *The Effects of Fooding on Water Relations and Growth of Theobroma cacao var. catongo Seedlings*. J. Hort. Sci. 61:265-276. Sena Gomes AR, Kozlowski TT, Reich PB. 1987. *Some Physiological Responses of Theobroma cacao var. catongo Seedlings to Air Humidity*. New Phytol. 107:591-602.
- Shamshuddin, J., Anda, M., Fauziah, C.I. & Omar, S.R.S. 2011. *Growth of Cocoa Planted on Highly Weathered Soil as Affected by Application of Basalt and/or Compost*. Communications in Soil Science and Plant Analysis, 42, 2751-2766.
- Shamshuddin, J., Muhrizal, S., Fauziah, I. & Husni, M. 2004. *Effects of Adding Organic Materials to An Acid Sulfate Soil on The Growth of Cocoa (Theobroma cacao L.) Seedlings*. Science of The Total Environment, **323**, 33-45.
- Sharifuddin, H. & Zaharah, A. 1991. *Utilization of Organic Wastes and Natural*

- Systems in Malaysian Agriculture*. First International Conference on Kyusel Nature Farming., pp. 71-78. Washington.
- Silva WS, Kummerow J. 1998. *Fine-root Growth and Longevity in A Cacao (Theobroma cacao L.) Plantation*. *Agrotrópica* 10:31-34.
- Simarmata, T., Y. Sumarni, & D.H. Arief. 2003. *Teknologi Bioremediasi untuk Mempertahankan Keberlanjutan Kesehatan Tanah dan Produktivitas Tanaman pada Ekosistem Lahan Kering dalam Era Pertanian Ramah Lingkungan di Indonesia*. Makalah dipresentasikan pada Seminar Kajian Keilmuan Pertanian Program Pascasarjana Universitas Padjadjaran Bandung 14 Juli 2003.
- Simmonds, N. W. 1998. *Tropical Crops and Their Improvement*. In *Agriculture in the Tropics* 3rd edition, 257–293 (Eds C. C. Webster and P. N. Wilson). Oxford, Blackwell Science. Simulations. Wageningen University, Department of Plant Sciences, Wageningen.
- Sleigh, P. A., Hardwick, K. and Collin, H. A. 1981. *A Study of Growth Periodicity in Cocoa Seedlings, with Particular Emphasis on The Root System*. *Café Cacao Thé* 25:169–172.
- Smaling, E., Nandwa, S., Prestele, H., Roetter, R. & Muchena, F. 1992. *Yield Response of Maize to Fertilizers and Manure Under Different Agro-ecological Conditions in Kenya*. *Agriculture, Ecosystems & Environment*, **41**, 241-252.
- Smethurst, P.J. 2000. *Soil Solution and Other Soil Analyses as Indicators of Nutrient Supply: A review*. *Forest Ecology and Management*, **138**, 397-411.
- Smilde, K.W. 1985. *Establishment of Fertilizer Recommendations on The Basis of Soil Tests*. Instituut voor Bodemvruchtbaarheid, Haren.
- Smith, R. W. 1964. *The Establishment of Cocoa Under Different Soil Moisture Regimes*. *Empire Journal of Experimental Agriculture* 32:249–256.
- Smith, S.E. and D.J. Read, 1997. *Mycorrhizal Symbiosis*. UK: 2nd edition, Academic Press; Cambridge
- Snoeck J. 1979. *Relations Entre Les Récoltes Mensuelles des Cacaoyers et Les Facteurs du Climat en Côte d'Ivoire, études Préliminaires*. *Café Cacao Thé* 23:277-282.
- Snoeck, D., Afrifa, A., Ofori Frimpong, K., Boateng, E. & Abekoe, M. (2010) Mapping fertilizer recommendations for cocoa production in Ghana using soil diagnostic and GIS tools. *West African Journal of Applied Ecology*, **17**, 97-107.
- Song, H . 2005 . *Effects of VAM on Host Plant in The Condition of Drought Stress and Its Mechanisms*. *Electronic Journal of Biology*,. 2005, Vol. 1(3): 44-4.
- Soria JN. 1970. *Principal Varieties of Cocoa Cultivated in Tropical America*. *Cocoa Growers' Bull.* 19:12-21.

- Soria SJ, Wirth WW, Pinho AFS. 1985. *A Polinização do Cacaueiro no Recôncavo Baiano, Brasil*. 1. Entomo- fauna comparada com a do Sul da Bahia. Rev. Theobroma 15:1-7.
- Soria VJ. 1963. *Observaciones sobre las variedades y cultivares de cacao en Bahía, Brasil*. Cacao 8:1-6.
- Soria VJ. 1964. *El Vigor Híbrido y su Uso en Mejoramiento Genético de Cacao. Fitotec. Latinoam.* 1:59-78. Soria JN (1970) Principal varieties of cocoa cultivated in tropical America. Cocoa Growers' Bull. 19:12-21.
- Sounigo O, Lachenaud P, Bastide P, Cilas C, N'Goran J, Lanaud C. 2003. *Assessment of The Value of Doubled Haploids as Progenitors in Cocoa (Theobroma cacao L.) breeding*. J. Appl. Genet. 44:339-353.
- Sparling. G.P. 1998. *Soil Microbial Biomass. Activity and Nutrient Cycling as Indicator of Soil Health*. Didalam Pankhurst, C., Doube, B.M. & Gupta, V.V.S.R. (eds). Biological Indicators of Soil Health. Wallingford: CABI Publishing.
- Stevenson A. 1987. *Cocoa: Fundamental Report*. E.F. Hutton Futures Division.
- Subba Rao, N. S. 1982. *Biofertilizers in Agriculture*. Oxford & IBH Publishing Co. New Delhi. Bombay. Calcutta
- Supply, 1–53 (Eds F. Ruf and P.S. Siswoputranto). Cambridge, Woodhead Publishing Ltd.
- Taiz, L. and E. Zeiger. 2003. *Plant Physiology*. California: The Benjamin/Cumming
- Taylor, S. J. and Hadley, P. 1988. *Relationships Between Root and Shoot Growth in Cocoa (Theobroma cacao L.) Grown Under Different Shade Regimes*. In Proceedings of the 10th International Cocoa Research Conference, Santa Domingo, Dominican Republic, May 1987, 177–183.
- Teoh, K. C., Chan, K. S. and Chew, P. S. 1986. *Dry Matter and Nutrient Composition in Hybrid Coconuts (MAWA) and Cocoa on Coastal Clay Soils*. In Proceedings of the International Conference on Cocoa and Coconuts: Progress and Outlook. Kuala Lumpur, Malaysia, October 1984, 819–835.
- Thangadurai. D Carlos A. B.Mohamed H. 2010. *Mycorrhizal Biotechnology*. CRC Press Taylor & Francis Group an informa business www.crcpress.com.
- Thompson, J.P. and V.B.D. Skerman. 1979. *Azotobacteriaceae: The Taxonomy and Ecology of the Aerobic Nitrogen Fixing Bacteria*. New York: Academic Press.
- Thong KC, Ng WL. 1980. *Growth and Nutrients Compositions of Monacrop Cocoa Plants on Inland Malaysian Soils*. In: Proc. Int. Conf. Cocoa and Coconuts,

- Kuala Lumpur, Malaysia, pp.262-286.
- Thong, K. & Ng, W. 1978. *Growth and Nutrients Composition of Monocrop Cocoa Plants on Inland Malaysian Soils*. International Conference on Cocoa and Coconuts, pp. 262-286. Kuala Lumpur.
- Thresh, J.M. & Owusu, G.K. 1986. *The Control of Cocoa Swollen Shoot Disease in Ghana: An Evaluation of Eradication Procedures*. Crop Protection, 5, 41-52.
- Toxopeus, H. 1985a. *Botany, Types and Populations*. Cocoa (eds G.A.R. Wood & R.A. Lass). London: Cadbury Schweppes.
- Toxopeus, H. and Wessel, M. 1970. *Studies on pod and bean values of Theobroma cacao L. in Nigeria. 1. Environmental effects on West African Amelonado with particular attention to annual rainfall distribution*. Netherlands Journal of Agricultural Science 18:132–139.
- Trolldenier, G. 1977. *Influence of Some Environmental Factors on Nitrogen Fixation in the Rhizosphere of Rice*. Plant and Soil 47: 203-- 302.
- Urquhart, D. 1955. *Cocoa*. London: Longmans, Green and Co.
- Valle RR, Silva WS, Miranda RAC. 1987. *Stomatal Resistance and Transpiration Rates of Shaded and Unshaded Cacao Trees*. Rev. Theobroma 17:175-187.
- Valle, R.R., De Almeida, A.-A.F. & De O. Leite, R.M. 1990. *Energy Costs of Flowering, Fruiting, and Cherelle Wilt in Cacao*. Tree Physiology, 6, 329-336.
- Van der Paauw, F. 1952. *Evaluation of Methods of Soil Testing by Means of Field Experiments*. Intern Soc Soil Sci. Joint Meeting, Dublin, pp. 207-221.
- Van der Paauw, F. 1956. *Calibration of Soil Test Methods for The Determination of Phosphate and Potash Status*. Plant and Soil, 8, 105-125.
- Van Himme, M. 1959. *Étude de Système Radiculaire du Cacaoyer*. Bulletin Agriculture du Congo Belge et du Rwanda-Urundi 50:1541–1600.
- Van Ittersum, M.K. & Rabbinge, R. 1997. *Concepts in Production Ecology for Analysis and Quantification of Agricultural Input-output Combinations*. Field Crops Research, 52, 197-208.
- Van Ittersum, M.K., Cassman, K.G., Grassini, P., Wolf, J., Tittonell, P. & Hochman, Z. 2013. *Yield Gap Analysis with Local to Global Relevance—A Review*. Field Crops Research, 143, 4-17.
- Van Noordwijk, M., Cerri, C., Wooster, P.L., Nugroho, K. & Bernoux, M. 1997. *Soil Carbon Dynamics in The Humid Tropical Forest Zone*. Geoderma, 79, 187-225.
- Van Vliet, Jiska A., Slingerland, Maja and Giller, Ken E. 2015. *Mineral Nutrition of*

- Cocoa. A Review. 57 pp. Wageningen University and Research Centre, Wageningen. ISBN 978-94-6257-705-3
- Vanlauwe, B. & Giller, K.E. 2006. *Popular Myths Around Soil Fertility Management in Sub-Saharan Africa*. Agriculture, Ecosystems & Environment, 116, 34-46.
- Varma, A. 2008. *Mycorrhiza, Genetics and Molecular Biology, Eco-Function, Biotechnology, Eco-Physiology, Structure and Systematics*. Third Edition Springer-Verlag Berlin Heidelberg ISBN 978-3-540-78824-9
- Vello F, Garcia JR, Magalhães WS, Nascimento IF. 1972. *Competição de cacaueiros híbridos*. In: Informe Técnico, Comissão Executiva do Plano da Lavoura Cacaueira, Centro de Pesquisas do Cacau, Ilhéus, Brazil, pp.17-24.
- Verlière, G. 1981. *Etude Par la Méthode du Diagnostic Foliaire de la Fertilisation et de la Nutrition Minérale du Cacaoyer (Theobroma cacao L.) en Côte d'Ivoire*. ORSTOM.
- Vernon AJ. 1967. *Yield and Light Relationships in Cocoa*. Trop. Agric. 44:223-228.
- Vernon AJ, Sundaram S. 1972. *Current Cocoa Research*. In: Proc. 4th Int. Cocoa Res. Conf., St. Augustine, Trinidad and Tobago, pp.689-693.
- Vieira DR, Müller MW. 2001. *Estudo Comparativo da Produção de Cacaueiros Autocompatíveis e Auto-incompatíveis do Híbrido SIAL 169 x P7 no Recôncavo da Bahia*. In: Proc. 13th Int. Cocoa Res. Conf., Kota Kinabalu, Malaysia, pp. 175-181.
- Vogel M. 197. *Recherche du Déterminisme du Rythme de Croissance du Cacaoyer*. Café, Cacao, Thé 19:265-290.
- Vogel M, Machado RCR, Alvim PT. 1982. *Remoção de órgãos Jovens Como Método de Avaliação das Interações Fisiológicas no Crescimento, Floração e Frutificação do Cacaueiro*. In: Proc. 8th Int. Cocoa Res. Conf., Cartagena, Colombia, pp. 215-222.
- Von Uexküll, H. & Cohen, A. 1980. *Potassium Requirements of Some Tropical Tree Crops (oil palm, coconut palm, rubber, coffee, cocoa)*. Potassium Requirements of Crops, pp. 71-104. Switzerland: International Potash Institute, Bern.
- Wachjar, A. dan L. Kadarisman. 2007. *Pengaruh Kombinasi Pupuk Organik Cair dan Pupuk Anorganik serta Frekuensi Aplikasinya terhadap Pertumbuhan Tanaman Kakao (Theobroma cacao L.) Belum Menghasilkan*.
- Walworth, J. & Sumner, M. 1987. *The Diagnosis and Recommendation Integrated System (DRIS)*. Advances in Soil Science, pp. 149-188. New York: Springer.
- Warren J, Sunita MK. 1995. *Isozyme Markers for Self- incompatibility and Yield in Theobroma cacao* . Heredity 74:354-356.

- Wessel, M. 1971. *Fertilizer Requirements of Cacao (Theobroma cacao L.) in South-Western Nigeria*. Communication 61, pp. 104. Amsterdam: Koninklijk Instituut voor de Tropen.
- Wessel, M. 1985. *Shade and Nutrition. Cocoa* (eds G.A.R. Wood & R.A. Lass). London: Cadbury Schweppes. Wichmann, W. 1992. *IFA World Fertilizer Use Manual*. International Fertilizer Association.
- Whatley JM. 1992. *Plastid Development in Distinctively Coloured Juvenile Leaves*. *New Phytol.* 120:417-426.
- Willmer C.M. & Fricker M. 1996. *Stomata*. London: Chapman & Hall.
- Wolf, J., de Wit, C.T., Janssen, B.H. & Lathwell, D.J. 1987. *Modeling Long-Term Crop Response to Fertilizer Phosphorus*. I. The model. *Agronomy Journal*, **79**, 445-451.
- Wood GAR. 1985. *Environment*. In: Wood GAR, Lass RA (eds), *Cocoa*, pp.38-78. London: Longman.
- Wood, G. A. R. 1985a. *Environment*. Chapter 3 in *Cocoa 4th Edition* (Eds G. A. R. Wood and R. A. Lass). Oxford, Blackwell Science, 38–79.
- Wood, G. A. R. 1985b. *From Harvest to Store*. In *Cocoa 4th Edition*, 444–504 (Eds G. A. R. Wood and R. A. Lass). Oxford, Blackwell Science.
- Wood, G. A. R. and R. A Lass. 2001. *Cocoa, 4th edition*. Oxford, UK: Blackwell Science.
- Wood, G.A.R. & Lass, R.A. 1985. *Establishment. Cocoa* (eds G.A.R. Wood & R.A. Lass). London: Cadbury Schweppes.
- World Cocoa Foundation. 2010. <http://www.worldcocoafoundation.org/learn-about-cocoa/cocoa-facts-and-figures.html>
- Wu, Q.S. and R.X. Xia, 2004. *Effects of Arbuscular Mycorrhizal Fungi on Plant Growth and Osmotic Adjustment Matter Content of Trifoliolate Orange Seedlings Under Water Stress*. *J. Plant Physiol. Mol. Biol.*, 30: 583-588.
- Zuzel, J.F. and J.L. Pikul Jr., 1993. *Effect of Straw Mulch on Runoff and Erosion from Small Agricultural Plots in Northeastern Oregon*. *Soil Sci* 156 (4): 111-117.
- Wyrley-Birch, E. 1972. *Manuring of Cocoa. Cocoa and Coconuts in Malaysia* (eds R.L. Wastie & D.A. Earp), pp. 136-142. Kuala Lumpur: Inc. Soc. of Planters.
- Yamada MM, Guries, RP. 1998. *Mating System Analysis in Cacao (Theobroma cacao L.)*. *Agrotrópica* 10:165-176.
- Yapp, J. H. H. and Hadley, P. 1994. *Inter-relationships Between Canopy Architecture, Light Interception, Vigour and Yield in Cocoa: Implications for Improving Production Efficiency*. In *Proceedings of the International Cocoa Conference: Challenges in the 90s*. Kuala Lumpur, Malaysia, September 1991, 332–350.

- YARA. 2012. *Yara Ghana Successfully Introduces Nitrobor on Cocoa Production in Ghana* (<http://www.yaraghana.com/News/YARA-GHANA-SUCCESSFULLY--INTRODUCES--NITRABOR-ON- C.aspx>). Accessed: July 2015
- Yegappan, T. M. and Mainstone, B. J. 1981. *Comparisons Between Press and Pressure Chamber Techniques for Measuring Leaf Water Potential*. *Experimental Agriculture* 17:75–84.
- Young, A. 1997. *Agroforestry for Soil Management, 2nd edn*. Wallingford :CAB International.
- Zingore, S., Delve, R.J., Nyamangara, J. & Giller, K.E. 2008. *Multiple Benefits of Manure: The Key to Maintenance of Soil Fertility and Restoration of Depleted Sandy Soils on African Smallholder Farms*. *Nutrient Cycling in Agroecosystems*, 80, 267-282.
- Zuidema, P. A., Leffelaar, P. A., Gerritsma, W., Mommer, L. and Anten, N. P. R. 2005. *A Physiological Production Model for Cocoa (Theobroma Cacao): Model Presentation, Validation and Application*. *Agricultural Systems* 84:195–225.
- Zuidema, P.A. & Leffelaar, P.A. (2002) *A Physiological Production Model for Cacao: Results of Model Simulations*. Wageningen University, Department of Plant Sciences, Wageningen.
- Zuzel, J.F. and J.L. Pikul Jr,. 1993. *Effect of Straw Mulch on Runoff And Erosion from Small Agricultural Plots in Northastern Oregon*. *Soil Sci* 156 (4): 111-117.

Tentang Penulis



Nasaruddin. Dilahirkan di Pattiro Bajo, Kabupaten Bone pada tanggal 6 Januari 1956 dan menyelesaikan pendidikan di SMA Neg. 1 Watampone pada tahun 1973. Pada tahun 1974 penulis melanjutkan pendidikan di Fakultas Ilmu-ilmu Pertanian Universitas Hasanuddin Ujung Pandang pada Jurusan Teknik Pertanian (Budidaya Tanaman) dan menyelesaikan studi pada tahun 1982. Menyelesaikan Program Pascasarjana (S2) Universitas Hasanuddin pada tahun 1994 pada Program Studi Sistem-Sistem Pertanian, Kajian Fisiologi Tanaman. Pada tahun 2012, penulis menyelesaikan Program Doktor (S3) Ilmu Pertanian Universitas Hasanuddin, Kajian Tanaman Perkebunan, khususnya kakao. Penulis diangkat menjadi dosen tetap pada tahun 1982/1983 di Fakultas Pertanian Universitas Hasanuddin. Pada tahun 1985, penulis dipercayakan mengasuh mata kuliah Fisiologi Tanaman, Nutrisi Tanaman Pengantar Agronomi, dan Budidaya Tanaman, Perkebunan sampai saat ini. Sebagai dosen, penulis banyak terlibat sebagai dosen luar biasa pada berbagai Perguruan Tinggi Swasta di Indonesia Timur dan dipercayakan mengasuh mata kuliah Fisiologi Tanaman dan Nutrisi Tanaman. Penulis mulai menulis buku Ajar sejak tahun 1998, walaupun belum diterbitkan. Buku yang sudah diterbitkan adalah (1) Kakao, Budidaya dan Beberapa Aspek Fisiologinya; (2) Budidaya, Hama dan Penyakit Tanaman Jarak; dan (3) Kakao; Pengenalan Klon, Rehabilitasi, Peremajaan, dan Intensifikasi (2012). Di bidang pengabdian pada masyarakat, penulis ditunjuk sebagai anggota Tim Teknis BIMAS Sulawesi Selatan dari tahun 1996-1999, dan pada tahun 1990-2000 ditunjuk sebagai Tim Konsultatif Pengembangan Hutan Kemasyarakatan di Indonesia Timur serta berbagai program pemerintah dalam pembangunan pertanian di Sulawesi Selatan. Selama ini, penulis banyak mencurahkan pikiran pada pengembangan tanaman perkebunan di Sulawesi pada umumnya dan khususnya di Sulawesi Selatan. Pada tahun 1995-1999, penulis aktif sebagai Tim Teknis Pengembangan Kopi dan Kakao di Sulawesi Selatan. Pada tahun 2000 sampai 2002 penulis termasuk pengurus dalam organisasi CCDC (Cocoa Cooperative Development Centre), dan tahun 2001-2002 sebagai sekretaris CCDC Sulawesi Selatan. Pada tahun 2006-2008 penulis menjadi staf ahli pada PT. JPN/PT. JOP. Sejak tahun 2009 sampai sekarang penulis ditunjuk oleh Pemerintah Kabupaten Bantaeng dan Pemerintah Kabupaten Wajo sebagai staf ahli pengembangan tanaman perkebunan. Pada awal Januari 2012, penulis juga ditunjuk menjadi staf ahli pada Fairways Capital Jakarta.



Muh. Farid BDR. Dosen Departemen Budidaya Pertanian, Fakultas Pertanian, Universitas Hasanuddin sejak 1992, menyelesaikan pendidikan sarjana S1 pada Fakultas Pertanian Universitas Hasanuddin pada tahun 1990, kemudian melanjutkan pendidikan S2 pada Universitas Gadjah Mada dan lulus pada tahun 1998 serta meraih gelar Doktor dalam bidang pemuliaan tanaman pada tahun 2009 pada Program Doktor Ilmu Pertanian, Universitas Hasanuddin. Penulis aktif melakukan penelitian di bidang perakitan varietas unggul tanaman pangan khususnya Jagung dan Gandum. Salah satu

pencapaian dari perjalanan karir akademik penulis adalah dihasilkan varietas Jagung toleran kekeringan dan nitrogen rendah yang diberi nama Sinhas 1 dari hasil kolaborasi dengan peneliti Unhas dan Balitsereal Maros. Penulis aktif terlibat dalam seminar baik pada level nasional maupun internasional dan beberapa karya ilmiah yang sudah dipublikasikan pada jurnal internasional bereputasi. Beberapa karyanya diantaranya adalah Genetic Parameters and Multivariate Analysis to Determine Secondary Traits in Selecting Wheat Mutant Adaptive on Tropical Lowlands yang dipublikasikan pada Plant Breed. Biotech. 2020, Vol. 8(4); Analysis of heritability and correlation of agronomic character towards the yield of several m6 generation of wheat mutants (*Triticum aestivum* L.) in the lowlands pada IOP Conf. Ser.: Earth Environ. Sci. Vol. 484, Juni 2020. Penulis merupakan Ketua Perhimpunan Pemuliaan Indonesia (PIRIPI) Komda SulSelBar. Selain itu juga aktif pada organisasi profesi seperti PERAGI dan berinteraksi dekat dengan petani dalam bentuk pendampingan Kelompok Tani untuk mendukung perbenihan tanaman pangan seperti padi sebagai bagian dari program Centre of Excellent (CoE) Unhas bekerjasama dengan ICDFTaiwan.



Ade Rosmana, dilahirkan di Tasikmalaya, Jawa Barat, Indonesia dan menghabiskan masa kecilnya disana. Dia memperoleh gelar sarjananya dari IPB University pada tahun 1980 dalam bidang Proteksi Tanaman, dan menjadi staf pengajar di Fakultas Pertanian, Universitas Hasanuddin sejak tahun 1981. Kemudian dia melanjutkan studi di Universitas Pierre dan Marie Curie Paris, dan, tahun 1990, memperoleh gelar Doktornya dalam bidang fitopatologi. Setelah satu tahun mengikuti program di USDA Rice Research Station Stuttgart, Arkansas, USA, dia menerima posisi sebagai kepala Departemen Hama dan Penyakit Tanaman dari tahun 1998 sampai dengan tahun 2002. Saat ini, beliau adalah kepala Laboratorium Penyakit Tanaman dan Cocoa Research Group, Fakultas Pertanian, Universitas Hasanuddin dan menekuni dalam pengendalian biologi hama dan penyakit padi dan kakao. Pada kakao, di tahun 2007 dia memperoleh USDA Cochran fellowship untuk mengunjungi Laboratorium USDA di Beltsville, Maryland, USA dalam rangka kerjasama penelitian pada penggerek buah kakao. Pada tahun 2010, dia kembali ke kota ini untuk kerjasama dengan Gary J. Samuels (USDA) dan Priscila Chaverri (University of Maryland) dalam penelitian patogen vascular streak dieback (VSD) dan *Trichoderma*. Sejak itu, dia memiliki minat yang besar dalam pengendalian patogen kakao dengan menggunakan agen biologi.



Abd. Haris Bahrun. Lulus S1 di Jurusan Budidaya Tanaman Fakultas Pertanian dan Kehutanan Universitas Hasanuddin 1993. Lulus Magister Sains tahun 1999 dan meraih gelar Doktor tahun 2012 pada Program Studi Agronomi di Sekolah Pascasarjana Institut Pertanian Bogor (IPB), dengan bidang keilmuan Ekofisiologi Tanaman. Bekerja di Departemen Agronomi Fakultas Pertanian Universitas Hasanuddin sejak 1994 - sekarang dan mengajar di program sarjana dan pascasarjana pada beberapa perguruan tinggi swasta di Makassar. Beberapa mata kuliah yang diampu adalah Agroklimatologi, Fisiologi

Tumbuhan, Ekofisiologi Tanaman Tropis, Fisiologi Pasca Panen, Budidaya Tanaman Perkebunan dan Industri. Penulis merupakan Sekretaris Program Magister Prodi Sistem-Sistem Pertanian Pascasarjana Unhas (2012-2014), Ketua Pengelola Aset Fakultas Pertanian Unhas (2012-2017), Kepala Laboratorium Agroklimatologi dan Biostatistika (2016 - sekarang), Ketua Program Studi S1 Agroteknologi (2020 - sekarang). Penulis telah menghasilkan 63 karya ilmiah dalam bentuk buku, makalah, jurnal yang telah dipresentasikan dan diterbitkan pada jurnal nasional dan internasional yang terindeks scopus. Penulis aktif pada beberapa organisasi profesi: Pengurus Pusat (Ketua V) Persatuan Perhimpunan Meteorologi Pertanian Indonesia (PERHIMPI) 2019-2024, Pengurus Pusat Persatuan Agronomi Indonesia (PERAGI) (2016 - 2019 dan 201-2023), Ketua Umum PERAGI Komisariat Daerah SULSEL (2021-2024), Ketua I Perhimpunan Hortikultura Indonesia (PERHORTI) Komda SULSEL (2021-2024), Ketua Biro Budidaya Dewan Kopi SUL-SEL (2019 -2024), Ketua Dewan Pakar, Ikatan Arsitek Lanskap Indonesia (IALI) SUL-SEL, Wakil Sekjen Pemuda HKTI Pusat (2006-2009), Sekretaris Dewan Pakar Himpunan HKTI DPD SUL-SEL (2020-2025), Ketua Departemen dan Kebijakan Organisasi Perhimpunan Ilmu Pemuliaan Indonesia (PERIPI) Komda SULSEL (2018-2022) dan Ketua Dewan Pengawas Persatuan Sarjana Pertanian (PISPI) SULSEL (2019-2022).



Ifayanti Ridwan. Lahir di Ujungpandang, 7 September 1974 menyelesaikan pendidikan di SMA Negeri 1 Makassar pada tahun 1992 dan melanjutkan pendidikan jenjang S1 pada Jurusan Agronomi, Fakultas Pertanian, Universitas Hasanuddin. Pada tahun 2000 mulai mengikuti pendidikan S2 pada Program Pasca Sarjana Universitas Hasanuddin dengan konsentrasi Tanaman pada Program Studi Sistem-sistem Pertanian kemudian mendapatkan beasiswa John Allwright Fellowship dari ACIAR Australia pada tahun 2003 untuk mengambil program Doktor pada School of Agricultural Science, University of Tasmania di Australia. Setelah mendapatkan gelar Doctor of Philosophy pada tahun 2009, penulis menjadi staf pengajar pada Program Studi Ekofisiologi Tanaman Tropis, Program Magister Agroteknologi, Universitas Islam Makassar dan mengampu Mata Kuliah Fisiologi Stres Tanaman sampai tahun 2012 dimana penulis mulai mengabdikan menjadi dosen tetap pada Departemen Budidaya Pertanian, Prodi Agroteknologi Fakultas Pertanian Universitas Hasanuddin. Beberapa Mata Kuliah yang diampu adalah Fisiologi Tumbuhan, Agroklimatologi dan Dasar-dasar Agronomi. Penulis merupakan Chief Editor Jurnal Dinamika Pengabdian sejak tahun 2015 sampai sekarang. Penulis telah menghasilkan beberapa karya ilmiah utamanya terkait kompetensi bidang ilmu penulis yakni ekofisiologi tanaman. Artikel yang telah diterbitkan antara lain Effect of temperature and water potential on sprout vigor of potato (*Solanum tuberosum* L.) seed tuber (IJAS, Vol. 2 No. 2, 2014), Effect of Temperature and Water Potential on Sprouting of Potato (*Solanum tuberosum* L.) seed tubers from different seed lots (Jurnal AGROTAN, Vol. 1 No.1, 2015), dan Changes in planting environment due to climate change likely to affect the pre-emergent growth of potato (*Solanum tuberosum* L.) having different seed tubers physiological ages (IOP Conference Series: Earth and Environmental Science, Vol. 235, 2019). Aktif pada organisasi profesi seperti PERAGI, PERIPI dan IALI, masing-masing menduduki jabatan sebagai koordinator bidang publikasi. Penulis juga menduduki jabatan sebagai Ketua Unit Publikasi Fakultas Pertanian Unhas sejak 2018 dan Kepala Sekretariat MWA Unhas sejak 2017 sampai sekarang.

Ekofisiologi Kebutuhan Air dan Nutrisi Tanaman Kakao

Buku Ekofisiologi, Kebutuhan Air dan Nutrisi Kakao membahas tentang tanggap tanaman kakao terhadap lingkungan tumbuh termasuk kebutuhan air dan nutrisi tanaman Kakao. Buku ini lahir dari pemikiran tentang pentingnya memahami respons fisiologis tanaman kakao terhadap perubahan lingkungan serta kebutuhan akan air dan nutrisi yang merupakan dua komponen penting untuk pertumbuhan dan produksi tanaman. Buku ini terdiri dari lima bab terdiri dari Pendahuluan, Karakter Pertumbuhan Tanaman Kakao, Ekofisiologi, Kebutuhan Air dan Kebutuhan Nutrisi Tanaman Kakao. Sangat diharapkan agar buku ini bermanfaat baik untuk digunakan oleh mahasiswa, peneliti, akademisi untuk pengembangan ilmu pengetahuan maupun kepada pengambil kebijakan dan masyarakat.

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