INTERNATIONAL JOURNAL OF ACADEMIC RESEARCH IN BUSINESS & SOCIAL SCIENCES

Vol 14, Issue 10, (2024) E-ISSN: 2222-6990

Improving Palm Oil Productivity through Harvesting Practices

Mohd Rafizan Samian, Adriana Mohd Rizal

Azman Hashim International Business School, Universiti Teknologi Malaysia, Malaysia

Email: mohdrafizan@graduate.utm.my

Corresponding Author Email: adriana.kl@utm.my

To Link this Article: http://dx.doi.org/10.6007/IJARBSS/v14-i10/23345 DOI:10.6007/IJARBSS/v14-i10/23345

Published Date: 16 October 2024

Abstract

The production of high-quality oil palm fresh fruit bunches (FFB) is important for palm oil growers, as it significantly impacts their income. The productivity of FFB does not depend solely on yield but also on the quality of FFB to achieve a high oil extraction rate (OER). This study examines the factors influencing the productivity of FFB in the oil palm industry, as well as strategies for improving harvesting practices and yield. The low productivity of FFB can be attributed to various factors, including suboptimal harvesting techniques, labour management challenges, pests and diseases, soil conditions, and smallholder practices. The review highlights the need for a holistic approach that addresses environmental conditions, agronomic practices, harvesting techniques, and technological interventions to improve FFB yields, oil extraction rates, and economic returns. Proper harvesting practices, such as maintaining optimal harvesting intervals, are crucial for maximizing productivity. The FFB need to be graded thoroughly to ensure a high OER. Future research directions include qualitative studies to gain in-depth insights from industry stakeholders and quantitative analyses to assess the effectiveness of interventions aimed at enhancing productivity and profitability in the oil palm industry.

Keywords: Palm Oil, Fresh Fruits Bunch, Productivity, Harvesting, Grading

Introduction

Palm oil plantations are deeply intertwined with global economic shifts, social development, and environmental impacts. Initially emerging in West Africa, the oil palm industry in Southeast Asia gained momentum due to access to land and labour (Robins, 2020; Watkins, 2022). Malaysia exemplifies how a developing nation became a global leader in palm oil production (Bruno, 2017).

Palm oil cultivation has a significant impact on smallholders, particularly in terms of income. Smallholders benefit from increased income, financial management improvements, and enhanced livelihoods through palm oil certification (Rosdin et al., 2023). However, challenges

such as price fluctuations due to global dynamics can make smallholders vulnerable, affecting their economic resilience (Euler, 2022). The adoption of oil palm cultivation by smallholders leads to higher farm sizes and increased income, positively contributing to their wellbeing and living standards (Daniel, 2022).

Recent palm oil plantation performance has shown resilience and progress despite challenges. Challenges faced by the palm oil industry include pests, diseases, climate change, and supply chain issues, necessitating international collaboration for mitigation (Monita & Dinda, 2023). Malaysian oil palm plantations have been impacted by workers' behaviour, with factors like efficacy, initiative, motivation, dependability, and cooperativeness significantly influencing performance (Syuhada et al., 2023). The industry is adapting to challenges by prioritizing yield enhancement, sustainability, and innovative processes, aiming for self-sustainability amidst economic and environmental challenges (Ahmad Parveez et al., 2020).
Palm oil plantation productivity and performance have been influenced by various factors. Research and development efforts to increase crude palm oil (CPO) yield per hectare are also ongoing. Therefore, this paper aims to review the literature on the factors influencing the productivity of FFB and the improvements that have been made to boost the income of oil palm growers.

Literature Review

Contributing Factors to Low Productivity of FFB

Harvesting Technique

Harvesting practices play a critical role in determining FFB productivity and oil quality. Improper harvest techniques, such as delays in evacuating harvested bunches, can lead to lower oil quality (Nadzar, 2020). Manual harvesting methods, relying solely on the harvester's knowledge and experience, can result in suboptimal timing, with Cherie et al. (2020) reporting that 15% of FFB were harvested at incorrect ripeness levels. Furthermore, poor management practices, including incomplete harvesting and inadequate agronomic management, have been identified as significant factors contributing to poor yields (Rhebergen et al., 2018). These findings highlight the importance of adopting optimal harvesting strategies, such as maintaining recommended harvesting intervals, harvesting only ripe bunches, and ensuring complete collection of all mature fruits, to maximize FFB productivity and oil extraction rates.

Labour Management

Effective labour management is crucial for maintaining optimal FFB productivity in oil palm plantations. A shortage of workers can lead to delays in evacuating harvested bunches, ultimately impacting oil quality (Nadzar, 2020). Moreover, low labour productivity has been found to directly affect FFB production levels (Zulkefli et al., 2020). Labor productivity itself is influenced by various factors, including wages, benefits, working climate, and appreciation (Zulkefli et al., 2020). Additionally, Dongoran et al. (2020) highlighted the significant influence of leadership style, work ability, and job satisfaction on job performance, which consequently impacts FFB yields. These findings underscore the importance of implementing strategies to enhance labour productivity, such as providing competitive compensation, fostering a positive work environment, and promoting effective leadership practices, to ensure efficient harvesting operations and maximize FFB productivity.

Smallholder Practices

Smallholder practices play a significant role in determining FFB productivity. To control transportation and labour costs, some smallholders resort to reducing harvesting frequency (de Vos et al., 2023). However, this strategy can lead to harvest losses from loose fruits and missed bunches, as well as a decline in oil quality due to the over-ripening of fruit bunches left on trees for extended periods. When deciding on harvest frequency, smallholders consider various factors such as annual FFB yield, total farm area, availability of reliable workers, accessibility of plantations, and FFB market pricing (de Vos et al., 2023). Additionally, the education background of smallholders has been found to have a significant impact on plantation productivity (Alwarritzi et al., 2015). These findings highlight the need for smallholders to adopt sustainable harvesting practices, informed decision-making, and knowledge-sharing initiatives to optimize FFB productivity while minimizing losses and maintaining oil quality.

Environmental Factors

Environmental conditions play a crucial role in influencing FFB productivity in oil palm plantations. Soil salinity has been identified as a significant factor, with lower FFB yields observed in saline-affected areas compared to unaffected plantations (Henry & Wan, 2012). Rainfall patterns play a significant role, with variations in precipitation levels affecting productivity (Asaad et al., 2022). Additionally, pests such as insects, mites, nematodes, rodents, and birds, as well as diseases affecting various parts of the plant, can hinder regular, healthy growth and drastically lower crop yields (Chung, 2012). Furthermore, factors like deficient pollination and resource limitation can lead to low fruit set, further impacting FFB productivity in hermaphroditic plants like the oil palm (Berjano, 2006). Addressing these environmental challenges through sustainable practices, integrated pest management, and strategies to enhance pollination and resource availability is crucial for optimizing FFB productivity and ensuring long-term sustainability.

Agronomic Practice

Various agronomic and management practices also influence FFB productivity in oil palm plantations. Fertilizer application rates are another critical factor, as proper nutrient management is essential for optimal plant growth and yield (Asaad et al., 2022). While the use of pesticides and chemicals may provide a solution for controlling pests and diseases, these measures can also have unintended consequences, such as killing natural pollinators (Chung, 2012). Furthermore, the number of plants per unit area can impact yields, as overcrowding or suboptimal planting densities can limit resource availability and productivity (Asaad et al., 2022). Land selection, planting materials, and technical management practices, such as pruning, weeding, and disease control measures, have also been identified as potential factors influencing FFB productivity (Salmiyati et al., 2014). Implementing best practices in agronomic management, including site-specific land selection, using high-quality planting materials, and adopting appropriate technical practices, can contribute to maximizing FFB yields and overall plantation productivity.

Improving the Productivity of FFB

Standard Harvesting Practice

The production of oil palm trees started the third year after planting, and a healthy tree will continue to produce fruit bunches throughout until replanting (Zulkifli et al., 2010). Good harvesting practice will produce high-quality FFB with a good OER and a high return in terms of money (Chew et al., 2021). Harvesting is an activity to cut and recover ripe bunches and usually involves teams of harvesters visiting blocks of palms at regular intervals (Mohanaraj & Donough, 2016). Harvesting requires achieving a balance between the need to maximize oil yield and oil quality while minimizing labour costs (Henson, 2012). FFBs are harvested using a variety of methods and tools, including mechanized harvesters (Nai Sowat et al., 2018).

The normal harvesting interval is 10 to 14 days (Henson, 2012). FFB is harvested based on the quantity of palm fruits that are separated from the bunch, commonly referred to as "loose fruits" (Chew et al., 2021). Harvesters rely on the loose fruits spread out around the tree's circumference as a measure of bunch maturity. Loose fruit has a significant oil content. Plantations could improve the OER to reach more than 24% if the loose fruits produced from the harvested FFB are fully collected and sent to the mill together with the FFB (Chew et al., 2021; Henson, 2012). The production of oil palm trees started the third year after planting, and a healthy tree will continue to produce fruit bunches until replanting (Zulkifli et al., 2010). Good harvesting practices will produce high-quality FFB with a good OER and a high return in terms of money (Chew et al., 2021). Harvesting is an activity to cut and recover ripe bunches and usually involves teams of harvesters visiting blocks of palms at regular intervals (Mohanaraj & Donough, 2016). Harvesting requires achieving a balance between the need to maximize oil yield and oil quality while minimizing labour costs (Henson, 2012). FFBs are harvested using a variety of methods and tools, including mechanized harvesters (Nai Sowat et al., 2018).

Harvesting practices should also focus on the quality of the yield to ensure better returns to the plantation (Mohanaraj and Donough, 2016). There is a positive relationship between ripe bunches and OER (Kamarudin, 2018). This means the plantation needs to ensure harvesting is done only on the ripe fruit bunches, and no unripe or underripe fruit bunches should be harvested to minimize losses to the plantation (Mohanaraj and Donough, 2016).

Other studies focused on optimizing harvesting operations. Mohd Kassim et al. (2012) developed a harvesting map displaying FFB locations and maturity stages to support harvesting operations. Escallón-Barrios et al. (2020) reduced the harvest cycle from 19.6 to 8.3 days on a plantation. Rhebergen et al. (2020) advocated increasing harvesting frequency and improving field access to close yield gaps in Ghana.

Grading of FFB

FFB grading is done after harvesting to check the quality and ripeness of the fruitlets according to the guidelines established by the Malaysian Palm Oil Board (MPOB) (Murad et al., 2015). Unripe fruit has no detached fruitlets from the bunch and shall be rejected by the mill upon delivery. Underripe fruit has at least one but fewer than ten fruitlets detached from a fruit bunch. This kind of ripeness will be accepted by the mill with a penalty. Ripe fruit is the

best quality of FFB and should have more than ten fruitlets detached, and more than 50% of the fruitlets are still intact in a fruit bunch. Meanwhile, an overripe fruit bunch has more than 50% of the fruitlets detached from the bunch.

The quality of FFB is graded manually through visual inspection of its physical characteristics, as stated in the guidelines. However, it is prone to error and disagreement because each harvester considers the bunch's ripeness differently (Hazir et al., 2012; Makky, 2013; Wan Ismail et al., 2009). Many studies have been conducted to introduce better tools for FFB grading purposes. A portable sensing device to assess the quality of fruits (Wan Ismail et al., 2009) and a vision technology camera are a few examples of technology used for grading (Shabdin et al., 2016). These innovative approaches offer several benefits, including high accuracy, consistency, convenience, and non-destructive measurement techniques, but the industry still relies on physical inspection for grading purposes. However, the reasons behind the slow adoption of these technologies have yet to be concluded by any literature.

Adapting Technological Advancement

Technological innovations were also explored. Jelani et al (2008), investigated using CantasTM, a tool that reduced estate labour requirements for harvesting by 50%. Khalid and Shuib (2014), evaluated the productivity and efficiency of two mechanical oil palm harvesting machines. Cherie et al (2020), developed an FFB colour model to identify the optimum harvest window for better oil extraction rates. Dzulkifli et al (2021), introduced a 360° camera system to predict FFB numbers per tree. Lim et al (2021), presented a mathematical model to determine the shortest distance for harvesting FFBs within a site. Recently, Mohamad et al (2022), designed an upper limb exoskeleton to assist oil palm harvesters. These studies collectively highlight various approaches to enhance harvesting practices for improved yields and productivity in the oil palm industry.

Discussion

The literature review highlights several factors contributing to low FFB productivity, including improper harvesting techniques, insufficient labour, and smallholder practices like reducing harvesting frequency to control costs. Environmental factors have a significant contribution and need to be managed with proper agronomic practices. These factors can lead to harvest losses and low OER.

Optimizing harvesting practices emerges as a critical intervention for enhancing FFB productivity. Maintaining optimal harvesting intervals, harvesting only ripe bunches, and ensuring complete collection of loose fruits can significantly improve oil yields and quality. However, the literature also reveals the prevalence of suboptimal practices, such as manual harvesting based on experience, incomplete harvesting, and delayed evacuation of bunches, which can lead to substantial losses.

The quality of FFB is typically graded manually through visual inspection based on guidelines from the Malaysian Palm Oil Board (MPOB). However, manual harvesting and grading methods are susceptible to errors and disagreements. The rejection of unripe FFB at the mill will incur a cost to the estate. Proper inspection of FFB needed to be conducted on-site to control the quality of production. Managers can address the issue directly with the harvester and avoid the repetitive occurrence of this incident.

While the literature acknowledges the potential of technological innovations, such as portable sensing devices and vision technology cameras, for accurate and consistent grading of FFB, their adoption in the industry remains slow. Understanding the barriers to adoption and developing strategies to facilitate the integration of these technologies could contribute to improved productivity and quality control.

Conceptual Framework

This study focuses on improving the productivity of palm oil through improved harvesting and grading of FFB to achieve high yield and OER. Improving the harvesting interval can enhance FFB yield by ensuring optimal maturity of the oil palm fruit, which directly impacts the quality of palm oil (Albakri et al., 2019). Synchronizing resources and strategically planning harvest cycles could help plantation managers minimize losses due to overripeness or uncollected fruit, ultimately leading to a higher FFB yield.

In addition, on-site grading of FFB will ensure only ripe FFB is transported to the mill. The quality of the harvest can also be assessed in real-time to improve harvesting quality and training needs. The cost of transport could be optimized, as no FBB will be rejected at the mill. Figure 1 provides an illustration of the conceptual framework of this study.

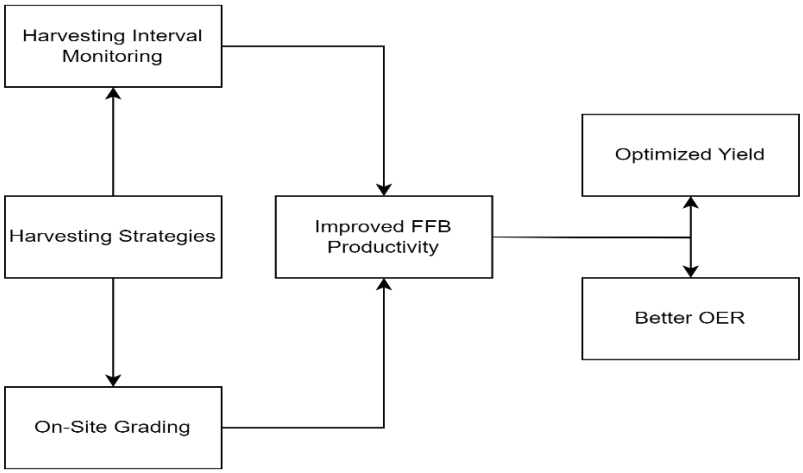

Figure 1: Conceptual framework to improve the productivity of FFB in palm oil plantations.

Conclusion and Future Studies

The productivity of fresh fruit bunches (FFB) in the oil palm industry is influenced by multiple factors, including environmental conditions, agronomic practices, harvesting techniques, labor management, and technological interventions. Addressing these factors through a holistic approach is crucial for improving FFB yields, oil extraction rates, and economic returns while promoting sustainability, especially for smallholder farmers.

Proper harvesting practices, such as maintaining optimal harvesting intervals, harvesting only ripe bunches, and collecting all loose fruits, play a vital role in maximizing oil yield and quality. On-site grading should be conducted to manage the quality of the harvest before it is transported out of the plantation to manage the quality and avoid any unnecessary losses to the palm oil grower.

A qualitative approach could help to further improve the understanding of productivity issues. Semi-structured interviews with the management of palm oil estates can provide in-depth insight based on their experience on-site. In addition, quantitative analysis of productivity metrics such as yield and OER could provide evidence on the effectiveness of interventions or initiatives taken to improve the income of the estate.

These future research directions can contribute to a deeper understanding of the challenges and opportunities in the oil palm industry, leading to evidence-based strategies for enhancing FFB productivity, economic returns, and environmental sustainability.

References

Albakri, Z. M., Mohd Kassim, M. S., Abdullah, A. F., & Harith, H. H. (2019). Analysis of Oil Palm Leaf Phyllotaxis towards Development of Models to Determine the Fresh Fruit Bunch (FFB) Maturity Stages, Yield and Site-Specific Harvesting. Pertanika Journal of Tropical Agricultural Science, 27(2).

Alwarritzi, W., Nanseki, T., & Chomei, Y. (2015). Analysis of the Factors Influencing the Technical Efficiency among Oil Palm Smallholder Farmers in Indonesia. Procedia Environmental Sciences, 28, 630–638. https://doi.org/10.1016/j.proenv.2015.07.074

Asaad, M., Karo, R., & Martial, T. (2022). Production Efficiency Analysis of Oil Palm Plantations: Stochastic Frontier Approach. International Journal of Research and Review (Baroda), 9(12), 678–686. https://doi.org/10.52403/ijrr.20221278

Asrol, M., Warid, H., & Ekawati, A. D. (2023). Triple Bottom Line Analysis and Assessment Towards Sustainable Palm Oil Plantation. E3S Web of Conferences, 388, 01027–01027. https://doi.org/10.1051/e3sconf/202338801027

Bruno, L. C. (2017). Palm Oil Plantation Productivity During the Establishment of The Malaysian Refinery Sector, 1970–1990. Economic History of Developing Regions, 32(3), 221–269. https://doi.org/10.1080/20780389.2017.1343660

Cherie, D., Rini, R., & Makky, M. (2020). Optical Properties of Oil Palm Fresh Fruits Bunch (FFB) For Optimum Harvest-Window Prediction. Journal of Physics: Conference Series, 1469(1), 012105. https://doi.org/10.1088/1742-6596/1469/1/012105

Chew, C. L., Ng, C. Y., Hong, W. O., Wu, T. Y., Lee, Y.-Y., Low, L. E., Kong, P. S., & Chan, E. S. (2021). Improving Sustainability of Palm Oil Production by Increasing Oil Extraction Rate: a Review. Food and Bioprocess Technology, 14(4), 573–586. https://doi.org/10.1007/s11947-020-02555-1

Chung, G. F. (2012). Effect of Pests and Diseases on Oil Palm Yield. Palm Oil, 163–210. https://doi.org/10.1016/b978-0-9818936-9-3.50009-5

Daniel, C. (2022). A Blessing in Disguise? Effects of Oil Palm Adoption on Smallholder Farmers' Wellbeing and Agricultural Transformation in Indonesia. https://doi.org/10.53846/goediss-8640

Vos, R. E., Nurfalah, L., Tenorio, F. A., Lim, Y. L., Monzón, J. P., Donough, C. R., Sugianto, H., Dwiyahreni, A. A., Winarni, N. L., Mulani, N., Ramadhan, G., Imran, M. A., Tito, A. P., Sulistiawan, P., Khoirul, M., Farrasati, R., Pradiko, I., Grassini, P., & Slingerland, M. A. (2023). Shortening harvest interval, reaping benefits? A study on harvest practices in oil palm smallholder farming systems in Indonesia. Agricultural Systems, 211, 103753–103753. https://doi.org/10.1016/j.agsy.2023.103753

Dongoran, A. P., Nazaruddin, & Wibowo, R. P. (2020). Analysis of effect of leadership style, work motivation and work ability to employee satisfaction in increasing performance of harvesters. IOP Conference Series: Materials Science and Engineering, 801, 012073. https://doi.org/10.1088/1757-899x/801/1/012073

Dzulkifli, I. J., Mohd Kassim, M. S., & Bejo, S. K. (2021). Development Of 360-Degree Imaging System for Fresh Fruit Bunch (FFB) Identification. Journal of Agricultural and Food Engineering, 1(4), 1–9. https://doi.org/10.37865/jafe.2021.0028

Escallón-Barrios, M., Castillo-Gomez, D., Leal, J., Montenegro, C., & Medaglia, A. L. (2020). Improving Harvesting Operations in An Oil Palm Plantation. Annals of Operations Research, 314(2), 411–449. https://doi.org/10.1007/s10479-020-03686-6

Euler, M. (2022). Oil Palm Expansion Among Indonesian Smallholders - Adoption, Welfare Implications and Agronomic Challenges. https://doi.org/10.53846/goediss-5103

Ahmad Parveez, G. K., Loh, S. K., Ong-Abdullah, M., Idris, Z., Hishamuddin, E., Mohamed Salleh, K., Zanal Bidin, M. N. I., Sundram, S., & Azizul Hasan, Z. A. (2020). Oil Palm Economic Performance in Malaysia and R&D Progress In 2019. Journal of Oil Palm Research, 32(2), 159–190. https://doi.org/10.21894/jopr.2020.0032

Hazir, M. H. M., Shariff, A. R. M., & Amiruddin, M. D. (2012). Determination Of Oil Palm Fresh Fruit Bunch Ripeness—Based on Flavonoids and Anthocyanin Content. Industrial Crops and Products, 36(1), 466–475. https://doi.org/10.1016/j.indcrop.2011.10.020

Henry, W., & Wan, H. (2012). Effects of salinity on fresh fruit bunch (FFB) production and oil-to-bunch ratio of oil palm (Elaeis guineensis) planted in reclaimed mangrove swamp areas in Sabah. Oil Palm Bulletin, (65), 12-20.

Henson, I. E. (2012). Ripening, Harvesting, and Transport of Oil Palm Bunches. In L. Oi-Ming, T. Chin-Ping, & A. Casimir C (Eds.), Palm Oil (pp. 137–162). AOCS Press. https://doi.org/10.1016/b978-0-9818936-9-3.50008-3

Jelani, A. Razak, Hitam, A., Jamak, J., Noor, M., Gono, Y., & Ariffin, O. (2008). CantasTM – A Tool for The Efficient Harvesting of Oil Palm Fresh Fruit Bunches – Journal of Oil Palm Research. Journal of Palm Oil Research, 20, 548–558. http://jopr.mpob.gov.my/cantastm-a-tool-for-the-efficient-harvesting-of-oil-palm-fresh-fruit-bunches/

Khalid, M. R., & Shuib, A. R. (2014). Field Evaluation of Harvesting Machines for Tall Oil Palms. Journal of Oil Palm Research, 26(2), 125–132. http://jopr.mpob.gov.my/field-evaluation-of-harvesting-machines-for-tall-oil-palms/

Lim, C. H., Cheah, Z. H., Lee, X. H., How, B. S., Ng, W. P. Q., Ngan, S. L., Lim, S., & Lam, H. L. (2021). Harvesting And Evacuation Route Optimisation Model for Fresh Fruit Bunch in The Oil Palm Plantation Site. Journal of Cleaner Production, 307, 127238. https://doi.org/10.1016/j.jclepro.2021.127238

Makky, M., & Soni, P. (2013). Towards Sustainable Green Production: Exploring Automated Grading for Oil Palm Fresh Fruit Bunches (FFB) Using Machine Vision and Spectral Analysis. International Journal on Advanced Science, Engineering and Information Technology, 3(1), 1. https://doi.org/10.18517/ijaseit.3.1.267

Mohamad, M. F., Sowat, S. N., Selamat, H., Azaman, A., & Harith, H. H. (2022). Structural Design of a Passive Wearable Exoskeleton to Assist Oil Palm Harvesting Operation. Journal of Oil Palm Research, In press. https://doi.org/10.21894/jopr.2022.0075

Mohanaraj, S., & Donough, C. (2016). Harvesting Practices for Maximum Yield in Oil Palm: Results from A Re-Assessment at IJM Plantations, Sabah. Oil Palm Bulletin, 72, 32–37. http://palmoilis.mpob.gov.my/publications/OPB/opb72-mohanaraj.pdf

Mohd Kassim, M. S. M., Ismail, W. I. W., Ramli, A. R., & Bejo, S. K. (2012). Oil Palm Fresh Fruit Bunches (FFB) Growth Determination System to Support Harvesting Operation. J. Food Agric. Environ, 10(2), 620-625.

Monita, C. F., & Dinda, D. (2023). Faktor-Faktor yang Mempengaruhi Produktivitas Kelapa Sawit di PT. Mustika Agung Sentosa. Jurnal Manajemen Agribisnis (Denpasar), 11(01), 231–231. https://doi.org/10.24843/jma.2023.v11.i01.p18

Murad, A. J., Awang, M. R., Mohamed, A. R., Osman, Z., Salleh, M. Z., & Ahmad, H. (2015). Manual Penggredan Buah Kelapa Sawit MPOB (3rd ed.). Lembaga Minyak Sawit Malaysia (MPOB).

Nai Sowat, S., Wan Ismail, W. I., Mahadi, M. R., Bejo, S. K., & Mohd Kassim, M. S. (2018). Trend in the Development of Oil Palm Fruit Harvesting Technologies in Malaysia. Jurnal Teknologi, 80(2). https://doi.org/10.11113/jt.v80.11298

Rhebergen, T., Fairhurst, T., Whitbread, A., Giller, K. E., & Zingore, S. (2018). Yield Gap Analysis and Entry Points for Improving Productivity on Large Oil Palm Plantations and Smallholder Farms in Ghana. Agricultural Systems, 165, 14–25. https://doi.org/10.1016/j.agsy.2018.05.012

Robins, J. (2020). Shallow Roots: The Early Oil Palm Industry in Southeast Asia, 1848–1940. Journal of Southeast Asian Studies, 51(4), 538–560. https://doi.org/10.1017/s0022463420000697

Rosdin, R., Cheah, W. Y., & Moslim, R. (2023). Systematic Literature Review on the Social and Economic Impacts of Palm Oil Certification on Smallholders. Malaysian Journal of Social Sciences and Humanities (MJSSH), 8(3), e002148. https://doi.org/10.47405/mjssh.v8i3.2148

Salmiyati, Heryansyah, A., Idayu, I., & Supriyanto, E. (2014). Oil Palm Plantations Management Effects on Productivity Fresh Fruit Bunch (FFB). APCBEE Procedia, 8, 282–286. https://doi.org/10.1016/j.apcbee.2014.03.041

Shabdin, M. K., Shariff, A. R. M., Johari, M. N. A., Saat, N. K., & Abbas, Z. (2016). A Study on The Oil Palm Fresh Fruit Bunch (FFB) Ripeness Detection by Using Hue, Saturation and Intensity (HSI) Approach. IOP Conference Series: Earth and Environmental Science, 37, 012039. https://doi.org/10.1088/1755-1315/37/1/012039

Syuhada, S., Rahim, M., Kamarulzaman, N., Nawi, N., Hanis, A., & Hadi, I. (2023). Behavioural Impacts of Workers on Performance: The Case of Malaysian Oil Palm Plantation. International Journal of Academic Research in Business and Social Sciences, 13(5), 1754–1775. https://doi.org/10.6007/IJARBSS/v13-i5/16857

Ismail, W. I., Razali, M. H., Ramli, A. R., Sulaiman, Md. N., & Harun, M. (2009). Development of Imaging Application for Oil Palm Fruit Maturity Prediction. Engineering E-Transaction, 4(2), 56–63.

Watkins, C. (2022). Oil Palm: A Global History. Agricultural History, 96(3), 453–455. https://doi.org/10.1215/00021482-9825340

Zulkefli, F., Syahlan, S., Bakar, M. A., Khalid, M. F., & Rakibe, I. (2020). Factors Influencing Labour Productivity in Oil Palm Estate. International Journal of Academic Research in Business and Social Sciences, 10(4). https://doi.org/10.6007/ijarbss/v10-i4/7114

Zulkifli, H., M. Halimah, Chan, K. M., Yuen May Choo, & W. Mohd Basri. (2010). Life Cycle Assessment for Oil Palm Fresh Fruit Bunch Production from Continued Land Use for Oil Palm Planted on Mineral Soil (Part 2). Journal of Oil Palm Research, 22, 887–894.