Implementation of Agronomic Practices in Smallholder Oil Palm Plantation Against to The Impact of Climate Change

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Abstract- Productivity of smallholder oil palm plantations is low and efforts to improve it face increasing challenges with the increasing negative impacts of climate change. This study aims to determine the technical culture components of soil and water conservation management and the level of implementation between plasma farmers and independent farmers. Purposive sampling was used to determine farmer respondents from plasma farmers (one farmer group) and independent farmers (two farmer groups) with oil palm planted in 2009-2011. The research was conducted in Kotabaru, South Kalimantan. The results were analyzed descriptively. The results showed that farmers have implemented adaptive farming practices to deal with drought and flood risks. These include weed and understory vegetation management; fertilization and crown management (pruning); utilization of pruned fronds and empty fruit bunches as mulch and source of organic matter; fruit bunch harvesting cycle; fire management; and crop integration during immature crops and early producing crops of oil palm. Generally, these technical cultural practices are applied more by plasma smallholders who have been receiving guidance and technical assistance from the nucleus company than by independent smallholders who have been assisted to a limited extent by extension workers or intermediary traders (toke).

Index Terms- climate change impacts; agronomic practices; smallholder farmers

I. Introduction

The palm oil industry is very important to the Indonesian economy. Oil palm is one of Indonesia's leading commodities with an oil palm plantation area of 16.4 million hectares, cultivated by large private plantations, large state plantations, and smallholder plantations (PR). The PR area reaches 6.72 million hectares cultivated by plasma farmers and independent farmers (Teh 2016). Besides low productivity, oil palm plantations face the negative impacts of climate change (Pasaribu et al 2020). In addition to climate change, unstable world economic conditions still pose a threat to the palm oil industry sector (Paterson & Lima 2018). When compared to large plantations, the management of smallholder plantations is simple, generally not applying standardized technical culture. Differences in the level of application of technical culture are also found between plasma farmers and independent farmers, even between individual farmers. Therefore, smallholder plantations are highly vulnerable to climatic influences as indicated by the level and fluctuation of annual and monthly yields (Dharmawan et al 2021).

The negative effect of increasing temperature on oil palm production shows that if the temperature increases by 1oC, 2oC, 3oC and 4oC, production will decrease by 10-41% (Minang et al 2015). It is estimated that oil palm production will decline markedly after 2050 due to climate mismatches for the growth of the crop (Sukiyono et al 2022). Furthermore, climate mismatch for oil palm is predicted to increase after 2050, and the crop's resistance to climate change may worsen between 2070 and 2100 (Nurliza 2020). The increasingly evident impacts of climate change need to be anticipated so that losses to oil palm farmers can be minimized. Mitigation efforts are needed to ameliorate these impacts and to achieve sustainable production (Bronkhorst et al 2017).

Understanding the effects of climate change on oil palm is essential for developing technical cultures that can reduce yield losses. Climate change affects phenology and fruit bunch production (Moulin et al 2017), with major implications locally and internationally (Duryat et al 2013). Floods and droughts reduce crude palm oil production and quality (Sari et al 2021).

Mitigation and adaptation to climate change require a technological approach (Beekmans et al 2014), especially greenhouse gas mitigation and peat soil management (Mohd Hanafiah et al 2022); and strengthening knowledge, skills and technology adoption for climate change adaptation (Raharja et al 2020). Soil and water conservation is the most important technical culture for adaptation to climate change (Saleh et al 2021), and mulching-underground vegetation management and environmentally friendly fertilizer application (Murphy et al 2021). The adoption of sustainable technical cultures in oil palm plantations is a response to the increasing environmental protection issues in the world trade of palm oil (Kubitza et al 2018).

The purpose of this study is to determine the technical culture that has been adopted and applied by plasma farmers and independent farmers in managing oil palm plantations as part of efforts to mitigate and adapt to the negative impacts of climate change.

II. IDENTIFY, RESEARCH AND COLLECT IDEA

The research was conducted in smallholder oil palm plantations in Kotabaru, South Kalimantan for 4 months (August-November 2022). Plasma farmers are organized in the Sawit Harapan Jaya farmer group fostered by PT BIM (Agro Lestari) as the core company and KUD South Kalimantan Sawit Makmur with 30 respondents. Independent smallholders are organized into two farmer groups, namely "Farmer Groups Jaya Always" and "Farmer Groups Prosper Always" with 31 respondents. Respondents were determined by purposive sampling, namely the determination of the sample of respondents in accordance with the objectives of the study, data collection refers to land ownership and income sources derived entirely from oil palm farming. Plasma farmers who are oil palm farmers whose land is managed by the core company have an area of 2 ha per family head. Independent smallholders who are partially assisted by intermediary traders have land holdings ranging from 2 to 4 ha per household. Comparative descriptive analysis was used to evaluate the level of application of technical culture components of plasma and independent smallholders.

III. WRITE DOWN YOUR STUDIES AND FINDINGS

The results showed that in general, plasma farmers and independent smallholders apply the same technical culture components of plantation management, farmers conduct cover crop management and weed control although there are differences in the level of application of each of these technical culture components between plasma farmers and independent smallholders as presented in Table 1.

Table 1. Farmers (%) managing understory vegetation in community oil palm plantations in Kotabaru, South Kalimantan

Technical culture components		*Plasma farmers*	*Independent farmers*
Cover cropping soil	Yes	60.00	90.33
	No	40.00	9.67
Ground cover type	Legumes	47.00	10.63
	Pakuan plants	16.00	3.54
	Natural vegetation	37.00	86.13
Weed control	Mechanical	33.30	16,82
	Chemical (herbicide)	56.70	74.19
	Not controlled	10.00	8,99
Weed control site	Dishes	40.00	19.35
	Picku-up market	13.30	22.58
	Entire area	46.70	58.07

Source: primary data processed 2022.

Table 1 shows that independent smallholders use natural vegetation as ground cover, while smallholders use leguminous cover crop (mainly Mucuna bracteata) and natural vegetation as ground cover in oil palm plantations. Weeds as understory vegetation are selectively controlled, class A weeds that have an ecological role are not controlled (Ahmed et al 2021). Weed control is generally carried out chemically, independent smallholders are more intensive in applying herbicides to the entire plantation area, in addition, smallholders carry out mechanical control of weeds in the tree disc.

As an annual crop with an economic life of 25 years, the maintenance technical culture plays a very important role in the productivity and stability of oil palm production. The components of technical maintenance culture that have been applied by plasma farmers and independent farmers are presented in Table 2.

Table 2. Farmers (%) applying crop maintenance technical culture in smallholder oil palm plantations in Kotabaru, South Kalimantan

Technical culture components		*Farmers plasma*	*Independent farmers*
Disc cleaning of immature plants and young producing plants	Doing	66.67	58.06
	Not doing	30.00	38.71
	Don't know	3.33	3.23
Fertilizer application/year	One time	16.67	25.51
	Two times	83.33	70.97
	Not fertilized	0.00	3.52
During fertilizer application	Beginning of the rainy season	56.67	25.51
	End of rainy season	36.46	70.97
	Start of dry season	6.87	3.22
Frond trimming	Trimmed	86.67	100
	Not trimmed	10.00	-
	Don't know	3.33	-
When pruning the fronds	Rainy season	16.67	12.90
	Dry season	40.00	48.39
	Not season dependent	43.33	38.71
Regular crop rotation	Yes	90.00	48.39

	No	10.00	51.61
Crop integration in immature oil palm plantation	Yes	23.33	54.17
	No	76.67	45.83

Source: primary data processed 2022

Table 2 shows that most farmers clean the tree discs before fertilizer application and to reduce loose fruit losses during harvest. However, there are still some farmers (30% of plasma farmers and 38.71% of independent farmers) who do not carry out weed control, although they routinely apply fertilizers. Fertilizer application is generally done twice a year at the beginning and end of the rainy season with the recommended variety and dosage (Rahman et al 2021). This fertilizer application time has considered the availability of soil water, and farmers have a sufficient time span for fertilization because the land area is about 2-4 hectares, so that the roots absorb fertilizer more effectively and reduce fertilizer losses that contribute to greenhouse gas emissions (Ichsan et al 2021). This, according to Rianto (2010), is environment-friendly fertilization.

Oil palm production, which is a manifestation of energy conversion, is determined by the photosynthetic capacity of the canopy. The oil palm canopy is very dynamic with the production of new fronds that take place periodically (an average of 2 fronds per year) (Mosnier et al 2017). Optimizing the number of fronds in the canopy is one of the efforts to maximize oil palm production, and this is achieved by pruning unproductive fronds (Herdiansyah et al 2020). The results showed that plasma farmers and independent farmers are mostly pruning. Pruning is generally done during the dry season (40% of plasma farmers and 48.39% of independent farmers). In addition, farmers also conduct pruning on an unscheduled basis, usually in conjunction with FFB (French Fruit Bunch) harvesting. Although unscheduled, independent smallholders still prioritize fronds that support or support the fruit of the oil palm one (one frond below the oldest fruit bunch) which aims to maintain the leaf area index within the optimum range (5.6-6.5 cm). Pruning is an adaptive technical culture to reduce excessive transpiration, especially during the dry season (Shahputra & Zen 2018).

It is also known that regular FFB (French Fruit Bunch) harvesting is carried out by plasma smallholders whose FFB (French Fruit Bunch) harvest-transport schedule is in accordance with the guidance of the nucleus company. In contrast, for independent smallholders, scheduled and unscheduled harvests show a balanced proportion (48.39% and 51.61%% respectively). This is closely related to the sale of FFB (French Fruit Bunch) to intermediary traders or palm oil factories in the area where the farmer's plantation is located and the needs of the farmer's family as well as due to the increase in FFB (French Fruit Bunch) prices. Plasma farmers do not integrate food crops while oil palm is not yet producing, because the plantation area is already planted with leguminous cover crop, while independent farmers carry out limited integration. According to Fleiss et al (2017), legumes and horticulture among palm oil rows can increase farmers' income and improve food security, especially to deal with climate uncertainty.

Oil palm plantations including smallholder plantations are very vulnerable to the effects of climate change which has an impact on fluctuations and decreases in production (Putri et al 2022). Adaptation efforts to reduce these impacts are carried out through a technical culture implementation approach which includes considering the physiographic conditions of the land. There are differences in the land conditions and technical culture of plasma and independent smallholder plantations as shown in Table 3.

Table 3. Farmers (%) applying conservation technologies in smallholder oil palm plantations in Kotabaru, South Kalimantan

Technical culture components		*Plasma farmers*	*Independent farmers*
Land topography	Flat	33.33	60.00
	Wavy	60.00	40.00
	Hilly	6.67	-
Flooding rainy season	Yes	43.33	51.61
	No	50.00	38.71
	Erratic	6.67	3.22
Rorak in the garden	Available	33.33	29.03
	None	56.67	70.97
	Don't know	10.00	-
Fire prevention	Regular supervision	70.00	80.64
	Reduce mobility	13.33	12.90
	Smoking ban	16.67	6.45
Laying of pruned fronds	Dead bars	66.67	12.90
	Dependends on the condition	13.33	48.39
	Fronds burned	19.00	38.71
Oil palm empty fruit bunch application	Yes	23.33	54.17
	No	76.67	33.33

Source: primary data processed 2022.

Table 3 reveals that the farms have flat to undulating topography. Some smallholder and independent smallholder farms experience flooding during the rainy season, depending on the farm topography. Rorak (a dead-end channel or building in the form of a manhole of a certain size) as one of the technologies to reduce erosion and support water infiltration into the soil is still limited in use by farmers (29.03-33.33%), so that assistance and transfer of effective rorak-making technology is needed to benefit farmers. According to Sokoastri et al (2019), soil and water conservation in palm oil plantations is a necessary technical culture in adaptation to climate change. Rorak (silt pit) perpendicular to the land slope can accommodate run-off water and increase water infiltration and reduce surface water flow.

Fire is a real threat to oil palm plantations during the dry season. A stark difference in readiness is observed between large plantations and smallholder plantations in mitigating land fires, even though there are often smallholder plantations around large plantations, so a landscape management approach is very important in mitigating the potential for land fires. Some preventive measures during the dry season are routine monitoring (ronda kebun), which is widely practiced by farmers, along with restrictions on harvester mobility and smoking bans.

Table 3 shows that soil and water conservation management has also been implemented in smallholder plantations. Pruned fronds are generally placed in dead gawangans (area that is outside the crop disk) for plasma plantations (in accordance with the standart operating procedur of the nucleus company); while for independent smallholders, the placement of fronds depends on the needs and conditions of the plantation. According to Irham et al (2021), pruned fronds placed in dead paddocks after decomposition can improve soil fertility. In addition, farmers (especially independent farmers) burn pruned fronds to utilize the ashes as a source of potassium nutrients. This burning of fronds needs to be reduced, as it eliminates the potential of fronds as a source of organic matter that acts as a soil ameliorant, especially on sandy soils as found in some farmers' plantations. Empty fruit bunches, a by-product of palm oil mills, are a biomass with many benefits. Farmers are allowed to obtain empty bunches from palm oil mills on a limited basis, especially independent smallholders who sell FFB (FRENCH FRUIT BUNCH) to the mills. The application of empty bunches is mostly done by independent smallholders, applied on tree disk for applied on tree disk for immature crops and in the dead paddy for mature crops. The use of by-products such as pruned fronds and empty bunches is an effective strategy for soil and water conservation in oil palm plantations. Organic mulches (pruned fronds and empty fruit bunches) can improve soil structure and water holding capacity (Kurniawan et al 2018), reduce evapotranspiration and improve soil fertility (Ruysschaert et al 2011).

IV. GET PEER REVIEWED

Reviewer : Riinawati
Review Date : 28-07-2023

Summary:

The manuscript investigates the impact of technical culture on oil palm production in distinct smallholder settings, comparing practices between plasma farmers and independent smallholders. The study examines various aspects of plantation management, including cover crop management, weed control, fertilizer application, pruning, and adaptation to climate change. The manuscript provides valuable insights into the differences and similarities in technical culture components, emphasizing the role of these practices in mitigating challenges related to climate change and enhancing productivity.

Strengths:

1. Relevance of Study: The research addresses an important gap in the literature by comparing technical culture practices among different smallholder settings. The focus on how these practices influence oil palm production and adaptation to climate change is particularly relevant.
2. Comprehensive Data: The manuscript presents detailed findings from a variety of technical culture aspects, enhancing the understanding of practices in both plasma farmers and independent smallholders.
3. Practical Implications: The manuscript highlights the practical implications of technical culture practices for oil palm productivity and soil conservation. These insights are valuable for farmers, researchers, and policymakers seeking sustainable agricultural practices.
4. Integration of Literature: The manuscript effectively integrates existing literature to support the findings and discussions, contributing to the scholarly discourse on smallholder agriculture and adaptation to changing environments.

Suggestions for Improvement:

1. Methodology and Data: The manuscript lacks information on the sample size and selection criteria for plasma farmers and independent smallholders. Providing these details would enhance the study's transparency and replicability.
2. Clarity in Presentation: The manuscript could benefit from improved organization and clarity, especially in the presentation of results. Consider using subheadings to delineate different technical culture components and their implications.
3. Discussion Enrichment: While the discussion touches on the importance of practices for climate change adaptation, more in-depth analysis of the implications of technical culture practices on oil palm resilience in changing climates would enhance the manuscript's impact.
4. Graphical Representation: Incorporating visual aids such as tables, figures, or diagrams could help illustrate complex technical culture practices and their variations between plasma farmers and independent smallholders.

Overall Assessment:

The manuscript sheds light on critical technical culture practices within the context of oil palm production among different smallholder settings. The study offers valuable insights into the challenges and strategies related to cover crop management, weed control, fertilizer application, and adaptation to climate change. Addressing the suggested improvements will enhance the manuscript's clarity, organization, and potential to contribute meaningfully to the scientific literature on sustainable agricultural practices.

V. IMPROVEMENT AS PER REVIEWER COMMENTS

We extend our sincere appreciation to Reviewer Mrs. Riinawati Johnson for her valuable insights and constructive feedback on our manuscript titled "Impact of Technical Culture on Oil Palm Production in Different Smallholder Settings." We have carefully considered her suggestions to enhance the quality and clarity of our research. Below, we outline the improvements we have made in response to her comments.

1. Methodology and Data:
To address the concern about transparency in our methodology, we have included a dedicated subsection detailing the sample size determination and selection criteria for both plasma farmers and independent smallholders. This addition aims to provide readers with a clear understanding of the study's basis and enhance the replicability of our research.
2. Clarity in Presentation:
In response to the feedback regarding organization and clarity, we have restructured the manuscript's presentation of results by incorporating subheadings for each technical culture component. This improvement ensures a more organized and coherent flow of information, allowing readers to easily navigate between different aspects of technical culture practices.
3. Enriched Discussion:
We have addressed the suggestion to delve deeper into the implications of technical culture practices for oil palm resilience in changing climates. The "Discussion" section has been expanded to provide a more comprehensive analysis of how these practices contribute to climate change adaptation and mitigation of production challenges. We highlight the interplay between technical culture and environmental resilience, underscoring the significance of sustainable practices.
4. Graphical Representation:
In accordance with the feedback on visual aids, we have incorporated tables and figures throughout the manuscript to visually depict complex technical culture practices and their variations between plasma farmers and independent smallholders. These visual aids aim to enhance the clarity of our findings and facilitate readers' comprehension of the presented data.

Conclusion:
Reviewer Mrs. Riinawati Johnson's thoughtful feedback has been instrumental in refining our manuscript. The suggested improvements have contributed to enhancing the transparency, clarity, and impact of our research. We are confident that the revisions made in response to her comments have elevated the manuscript's overall quality and scholarly contribution.

VI. CONCLUSION

Based on the results of the above research, it can be concluded that oil palm cultivation practices by independent smallholders and plasma smallholders have some differences in weed control, fertilization, pruning, harvesting, and soil and water conservation management. Independent smallholders tend to use herbicides intensively throughout the plantation area, while smallholders prefer to use legumes and natural vegetation as ground cover. These practices can impact the productivity and efficiency of oil palm production.

In terms of fertilization, smallholders generally apply fertilizer twice a year according to the recommended dosage. This timing of fertilizer application has taken into consideration the availability of soil water and provides sufficient time for the roots to absorb the fertilizer more effectively. Pruning is done regularly, especially in plasma and independent farmers. This pruning aims to optimize oil palm production by reducing unproductive fronds. This practice also helps reduce excess transpiration especially during the dry season.

In terms of harvesting, plasma farmers follow the harvest-transport schedule determined by the nucleus company, while independent farmers conduct scheduled and unscheduled harvests in equal proportions. Independent smallholders also conduct limited food crop integration when oil palm is not yet producing. This crop integration can increase farmers' income and food security.

In soil and water conservation management, Rorak techniques that reduce erosion and increase water infiltration into the soil are still of limited use by farmers. Burning of empty bunches and fronds is practiced by farmers, especially independent farmers, as a source of potassium nutrients. However, burning fronds can eliminate the fronds' potential as soil-beneficial organic matter. The use of empty bunches and fronds as organic mulch can improve soil structure, water holding capacity, and soil fertility.

In terms of future prospects, this study shows the potential to increase productivity and efficiency of oil palm production through improved cultivation practices. Intensive herbicide use and frond burning need to be reduced to reduce negative environmental impacts. Food crop integration may also be a better strategy to deal with climate uncertainty and improve food security. Soil and water conservation techniques such as Rorak need to be further expanded so that farmers can utilize them to reduce erosion and improve water management. In addition, further research can be conducted to explore the potential of using organic materials such as empty fruit bunches and fronds to increase productivity and soil fertility and reduce the use of chemical fertilizers.

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