

# TECHNICAL CULTURE AND PRODUCTIVITY OF OIL PALM IN SEVERAL PLANTATIONS IN EAST KALIMANTAN

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*Abstract - Plant productivity is determined by two main interrelated factors, namely, the application of technical culture factor, including the use of superior plant materials, and soil suitability factor. Therefore, it was necessary to conduct a research that aimed at finding out the actual productivity of oil palm plantations cultivated and properness of the application of technical culture carried out, and relationship between the application of technical culture and productivity achieved at the level of land suitability of the cultivated land. The study was conducted by taking samples from five oil palm plantations in East Kalimantan with a total area of 85,000 ha ±. The research used primary and secondary data related to the aspects of production, technical culture and land suitability. The secondary data were collected through studies on the enterprises' reports and research results whereas the primary data were collected by direct observation and measurement of the fields, and then the data were analyzed using statistical analysis. The results showed that the productivity of FFB and CPO produced by the oil palm enterprises in the area of research is still low when compared to the potential baseline of productivity of land with the same suitability classification (S3 or Marginally Suitable) where the FFB productivity reached 78.96% and CPO productivity reached 76.63% of the potential baseline of the productivity of S3 Land Suitability Classification (LSC). The low level of productivity is thought to be caused by the level of application of technical culture which has not met the baseline of the recommended standards of technical culture where the technical culture application errors occurred ranged from 0.05 to 7.58%, and the estimated effect toward the decline in production reached up to 65%. The technical culture application errors occurred in the nursery stage, immature plants (TBM) and mature plants (TM).*

**Keywords** - Palm oil, Technical Culture, Productivity, Plantation, Land Suitability.

## 1. INTRODUCTION

Productivity of Fresh Fruit Bunches (FFB) and Crude Palm Oil (CPO) per hectare of an oil palm plantation is the most important indicator in measuring the efficiency and effectiveness of the plantation. The productivity of the oil palm plantation achieved at the same time can also be a measure whether the cultivated plantation industry is economically viable. Long-term economic viability of all palm oil crop production systems relies on the implementation of best developed practices (BDPs) [1]. Palm productivity is determined by two main factors that are interrelated, namely, the application of technical culture and land suitability. Therefore, it becomes important to know how far the proper application practice of cultivation technical culture has been carried out and to identify the cultivated land suitability classes. For example, the management of palm crop residu for the crop cycle period of 25-30 years can still improve the synchronization of nutrients and beneficial effects from the decay of palm crop residue organics on the soil properties, thus enhancing oil palm production [2].

As it is known that the land suitability classes in East Kalimantan utilized as oil palm plantations currently have a low suitability class, so that the land utilization is in need of supports for the implementation of a good technical culture.

Methods of residue management and oil palm planting can increase the spatial integration of nutrient release so that it can be absorbed by young palm root systems. The management method of palm crop residu for the crop cycle period of 25-30 years can still improve the synchronization of nutrients and beneficial effects from the decay of palm crop residue organics on the soil properties, thus enhancing oil palm production [2].

During the replanting of oil palm, a large amount of oil palm residue available in the soil which contributes about 577 kg N/ha and 40 ton C/ha and root material produced reaches about 65 kg N/ha and 8 ton C/ha. These materials are the main sources of C and N that will affect C and N mineralization in the soil. N mineralization potential, C organic mineralization through soil respiration and CO<sub>2</sub> evolution with management practices of different residues can be estimated [3]. Management of nutrient balance (nutrients) is BDPs which are the most important stage, and they have been developed at a specific location and reduce costs in the production of palm oil [1].

If these conditions are not met, then the growth and development of cultivated plants are not optimal. Mineralization of nitrogen from crop residue inputs can increase the availability of N for young palm as much as 428

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kg N/ha/year which are obtained from the mineral soil and available for the plants. In contrast, the mineralization of N from crop residues from the tracks without having residues from the harvest contributes only about 312 kg N/ha/year that may be derived from the decomposed roots from the previous harvest. Thus, the flux of about 109 kg N/ha/year is transferred to the soil as a consequence of the crop residues which are left above the soil during the replanting activity. An amount of N in the labile pool of light organic material fraction accumulates on the top surface of the soil when mineralized is six to seven times higher than the organic layer underground [3].

These conditions ultimately make the cultivation of oil palm become unprofitable. By knowing the actual picture of the application of technical culture, land suitability classes and the level of productivity of cultivated plantations, an evaluation against the problems that lead to not achieving the productivity potential standard set for the plant varieties can be conducted. This can also answer the complaints of the planters who claim that the actual production achieved is often lower than its production potential.

**2. METHOD**

**2.1. Location and Time of the Research**

The experiment was conducted in East Kalimantan Province with the research objects of 5 oil palm plantation enterprises. The determination of the 5 examples was conducted by purposive sampling. Administratively, these plantations are located in Kutai Regency, East Kutai Regency and Paser Regency with a total area of ± 85 225 ha, and the study was conducted from July 2012 to July 2013 (Fig.1).

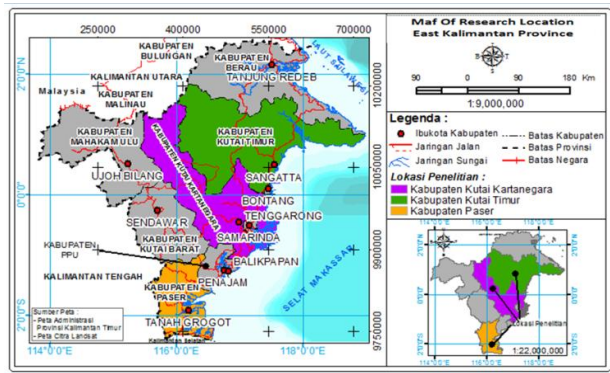


Fig 1. Research Location

**Types and Sources of Data**

The primary data were collected by means of observation and measurement, and the secondary data were collected through desk study on the data containing reports of the agronomic activities of the enterprises.

**2.2. Data Analysis**

The number of plots or planting blocks which were the samples to be observed or measured was 10% of the total areas of the five plantations i.e., ±8,500 ha. In the sample plots, an observation point was determined for the measurement of the whole required parameters of key technical culture. The data from the measurement result were analyzed using a statistical method. Evaluation on the technical application of agronomy was divided into 3 groups

of activities, namely: Nursery, Immature Plants and Mature Plants. Guidelines for key technical culture and the estimated value of losses incurred due to the technical faults on the production refer to the guidelines published by the [4]. The data of suitability classification data and soil types included the secondary data from the results of land suitability evaluation conducted by the companies. The guidelines for land evaluation system used were compiled by [5]. Collection and analysis of data on production and productivity were conducted by observations and studies on the plantation production reports and on palm oil factories (MCC). The guidelines for FFB and CPO productivity standards which become the comparator are the baseline standards of the productivity published by the Research Centre for Oil Palm [6]. The results of keys parameters measurement of technical culture are then compared with keys parameters of the Research Centre for Oil Palm. A research on the productivity of the production of fresh fruit bunches (FFB) and crude palm oil (CPO) was conducted and limited to young oil palm trees aged from 3 to 8 years.

**3. RESULTS AND DISCUSSION**

**3.1. The application of key technical culture at the nursery stage**

The parameters of the nursery activities evaluated included: the delay in transporting the seeds from the pre-nursery to the main nursery, from the main nursery to the field, and the condition of the seeds transferred to the field. The data from the evaluation results on the application of the key technical culture at the nursery stage showed that the application did not comply with the technical standards recommended (Table 3). The error values of application of the key technical culture ranged from 2.44% to 7.58%, and the errors are estimated to result in losses to yields between 15% in year 1 and 40% in year 4.

**Table 3 Recapitulation of the results of the evaluation on the application of technical culture at the nursery stage**

No.	Indicators	Error Values (%)	Impacts	Estimates of losses to the yields *)
1.	The number of <i>pre</i> nursery seeds which were very late to be transferred to the main nursery	4.56	Low harvest yields in year 1 and year 2	- 40%
2.	Total of main nursery seeds which were very late to be planted in the field i.e. over 16 months	7,58	Low production in year 1 and year 2	- 15%
3.	Total of seeds which were very young to	2,44	Low production in year 1 and	- 26%

	be planted in the field i.e. < 9 months		year 2 Low production in year 1 and year 2	
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\*). The Research Center Standards of Oil Palm (PPKS) Medan

### 3.2 Application of the key technical culture of Immature Plants (TBM)

The data of the evaluation on the application of technical structure of immature plants (TBM) showed that there was an error in the application from the planting to maintenance activities of the plants (Table 4). The error value ranged between 0.05% -1.61%, it is estimated to result in losses to the FFB yields between 0.96% in year 1 and 65% in year 7.

**Table 4 Recapitulation of the results of the evaluation of the application of technical culture on Immature plants (TBM).**

No.	Indicators	Error Value (%)	Impacts	Loss estimation on the harvest yields *)
1.	Total of unproductive plants planted in the field (ha).	0,70	Dwarf trees	- 0,96 (ton/ha/year) (at the plant density of 143 trees/ha)
2.	Total of plants planted in shallow depth, in very deep depth, and in sloping condition (ha).	1,17	Disturbed and imperfect plant growth	- 65% (harvest of 1 to 3 years of the first cycle)
3.	5 unproductive trees existed per ha (ha)	0,99	Unproductive plants	1 ton/ha/year of the loss of harvest yield (for every 5 unproductive trees/ha)
4.	Existence of death stake points due to errors in staking (ha)	0,86	Reduction in the number of trees per hectare (2 trees/ha)	- 11% (for 3 years)
5.	The area width left unplanted with LCC (ha).	0,33	LCC was not found in the planting areas	- 16% (for 3 years)
6.	The existence of Dura plants (ha)	0,15	Planting contaminated by Dura	-18% OER (when compared with the

				tenera)
7.	The area total filled with uncontrolled mekania weed (ha)	0,14	Uncontrolled Milkania Weed on young oil palm trees	- 21% (Cumulative yields from 4 years to 7 years)
8.	Achievement in fertilizing program was below the standards (%).	1,61	Failure in Fertilizing Program	- 15% toward the FFB yields
9.	Errors in fertilizer application technique (ha).	0,15	Fertilizing unevenly distributed at the harvest path	- 5% toward the FFB yields
10.	Number of plants excessively pruned (ha).	0,28	Total of fronds fewer than the standard total.	- 25% (kg/tree/year) Due the increase in flower abortion
11.	Number of plants attacked by the leaf worms (ha).	0,08	Significant damage on the plant leaves	- 40% (for the following 2 years)
12.	Number of plants attacked by the beetles (ha).	0,05	Damages on leaves and youngest leaves	Harvest Year 2/-50%, 3/-31% and 4/-42%
13.	Number of plants attacked by the rats (ha).	0,32	Fronds eaten by the rats.	-7 s/d -10% from the CPO production

\*). Research Center Standards of Oil Palm (PPKS) Medan

### 3.3. Application of technical culture at Plant Produces (TM)

The data on the evaluation results on the application of key technical culture in Mature Plants showed that there was a misapplication of the key technical culture at harvest and transport of the harvest yields (Table 5). The error values ranged between 0.34% and 1.80% and the error is expected to result in yield losses to between 3% and 15%.

The amount of losses incurred due to errors in the application of technical culture is very influential at the nursery stage on the growth and development of plants when they grow in the field. Nursery health will be influential on the plants' adaptability to their field and their resistance to pests and diseases. Nursery is the first step in planting oil palm whose aim is to provide good, healthy and in sufficient quantities of seeds [7]. From the proper nursery process,

superior seeds will be obtained, and this indicates their potential to produce optimal production [8].

The less optimum application of technical culture on Immature Plants (TBM) occurs, among others, in the following activities: from oil palm planting, land cover crop planting, fertilizing, weed control, pest and disease control to harvest preparation activities, and these errors have reduced the FFB production. According to [6], the technical errors on Immature plants (TBM) will directly or indirectly give impacts on the growth and development of the plants.

**Table 5 Recapitulation of the evaluation results of the errors in the application of key technical culture on producing plants (TM).**

No.	Indicators	Error Value (%)	Impacts	Loss estimation on the harvest yields *)
1.	The total of plants with imperfect pollination (ha)	0,34	Disturbance in fruit formation	-3 to 4% OER -1,5% KER
2.	The total of plants experiencing harvest technical failures and whose loose fruits were not collected > 5 fruits (ha).	1,80	Loose fruits were not collected at the harvest path	> - 15% OER

\*) Research Center Standards of Oil Palm (PPKS) Medan

Regarding this, [9] reveals that the application of cultivation technology (plant maintenance, fertilization, pest and disease control) included in the aspect of Best Management Practices (BMPs) will greatly affect the productivity of plants so that the practices (BMPs) must be conducted properly, and this is in line with the government programs that encouraged the oil palm plantation industries in Indonesia to implement BSM program consistently in order to achieve the productivity targets for an average of 20 tons of oil palm FFB/ha/year in 2025.

The role of oil palm production on Land Use Cover in the future greatly depends on the size of the expansion projected and agricultural management factors as well as implementation of best management practices (BMP), earlier replanting with taller harvested plants and development of new plantations on degraded land [10].

Proper fertilization which is part of the implementation of the technical culture has not been properly implemented by the enterprises in the research areas. According to [11], fertilizing management plays an important role in the productivity and profitability of oil palm plants. Sometimes,

high price of fertilizer or low price of palm oil also affects the consideration in conducting fertilization. The basic framework of fertilization technique, recommendations, and sufficient knowledge are essential to implement a strategy to overcome the difficulties in dealing with the problem of economic uncertainty regarding the fertilization.

In addition to the fertilizing problem, pest and disease control has also not been optimally conducted. According to [12], Integrated Pest Management (IPM) is the key to the integrated pest control in order to achieve sustainable plantation development. The aim is to adopt the traditional culture, to prioritize the biological or mechanical control so that the hazards of pesticide use can be reduced.

Incomplete pollination and harvest technical errors in Mature Plants (TM) are factors that encourage low productivity of crops. Based on the researches by [6], the number of successfully pollinated flowers was decreasing, and the bunch weight (*berat janjang*) was also decreasing because the fruits in the bunches contain were not solid, thus resulting in extremely low quantity of oil. Harvesting technical faults both for unripe fruits and excessively ripen fruits will affect the CPO produced in terms of both quality and quantity. According [13], the increase of the harvest yields can be achieved through the implementation of Best Management Practices (BMPs), harvest regulation, and fulfillment of the plant population per hectare, and they become the pre-requisites in reducing the yield gaps. However, it should be noted that the success of the program depends on the commitment of BMP top management to provide directions, budget allocations, and other resources, and the plantation-level managers must implement the these practices strictly and efficiently.

#### Land suitability classification and soil types

The data of evaluation results on land suitability performed by each of the enterprises studied showed that the land suitability classification was S3 (Marginally Suitable) and N (Marginally Unsuitable). The land width of S3 classification (Marginally Unsuitable) was  $\pm 77,985.20$  ha or 91% and the suitability classification of N (Marginally Unsuitable) is  $\pm 7,240$  ha or 8% of the cultivated land area ( $\pm 85,225.20$  ha). According to [14], land suitability classification is a condition that describes the degree of suitability of a piece of land in the semi-detailed level which will provides information on land suitability which can be applied for the operational needs in the field. As explained by [15] and [16], the suitability is adaptability of land for a particular use.

The main limiting factors for the plantations in the research area included soil acidity, poor drainage, coarse soil texture, and slope. As for the land suitability classification of N (marginally unsuitable), the limiting factors included poor soil drainage, steep slopes and rock surface. The types of soils in the research areas include Entisols, Ultisols and Inceptisols. These limiting factors will greatly affect the growth and development of the oil palm plants. However, according to [17], oil palm plants (*Elaeis queneensis* Jacq) have a reasonably high tolerance and can grow at the diverse soil characteristics soil with a fairly wide interval on various soil types ranging from organic soil of Histosol to mineral soils of Andisol, Entisol, Inceptisol and Ultisol. The results of the study by [18] showed that most areas of Kalimantan are

wet, and their rainfall is > 200 mm/year, reaching 4,000 to 6,000 mm/year. These areas have precipitation types of A and B, Oldeman agro-climatic zone of A or B1/B2, and udic and humid agro-climate zones. The soils formed in the wet tropical climate (humid), the weathering process is very intensive, and the soils generally have a deep cross-section with yellowish red color and become acid with high Al saturation, and their natural fertility is low.

According to [19], each land characteristic will affect the growth and development of oil palm plants cultivated. High soil acidity, poor soil drainage and coarse soil texture or high content of sand will affect the growth of plants. In regards to soil acidity, the effect mechanism is through an increase of Fe, Al and Mn solubility which are toxic to plants, a decrease in the concentration of nutrient cations, a decrease in P and Mo solubility, inhibition in root growth and water uptake, direct plant cell damage as a result of an increase in the concentration of H<sup>+</sup>. In addition, there will be constraints in nutrient availability and absorption. Meanwhile, the sloping area requires high cost for soil conservation and complicates the process of harvesting and transporting the FFB. The BMP implementation begun with the selection of suitable land will ensure the optimal plant population size, prevent erosion, arrange the planting space, maintain the availability of nutrients by fertilizing based on soil fertility classification, and immediately transport the fruits harvested according to the plantation standard operational procedures (SOP) which greatly determine the productivity of the plantation.

Proper selection of soil is also part of the BMP. Selecting land requires a feasibility study beforehand, and if this feasibility study on the area to be developed is not conducted, it is possible that the land selected may not be suitable. A number of problems regarding its use appear, and to avoid such problems, it is suggested that the best practice for oil palm development involve the initial investigation on the soil or land or land at least through a preliminary study to assess the potential of the land [20].

**Productivity of FFB and CPO in the research plantation areas**

The research results on the productivity of FFB and CPO of each plantation are presented at Table 4 and Table 5. The average of the productivity of FFB and CPO in the 5 plantations were compared with the productivity baseline potential of FFB in the same Land Suitability Classification (MPA) of S3.

From the evaluation data, it can be seen that the average productivity of TBS on the research areas only reached 12.66 tons/ha/year or 78.96% of the baseline of the productivity potential of FFB at the level of the Land Suitability Classification (MPA) of S3. The CPO productivity also reached 3.87 tons/ha/year or 76.63% of the baseline of the productivity potential of CPO at the level of productivity of CPO at the level of the Land Suitability Classification (MPA) of S3.

The figure of the productivity of FFB in this study was slightly higher than that of the study conducted by [17] who stated that productivity of oil palm FFB in Ultisol soil in the region of Kalimantan was lower than that in Riau and North Sumatra i.e. between 61.2 and 72.7% of the baseline of the production potential on Land Suitability Classification (MPA/LSC) of S3.

This is also consistent with the results of the study conducted by [21] who concluded that the actual productivity achieved in the cultivation of oil palm, in fact, is often not in accordance with the productivity potential of the cultivated land.

**Table 4 The productivity of FFB (tons/ha/year) based on the age of the plants in each plantation company.**

Plant Age	Productivity of CPO						Baseline of Production at the LSC of S3 *)
	Plantation 1	Plantation 2	Plantation 3	Plantation 4	Plantation 5	Average	
3	3.31	4.10	3.23	2.60	4.31	3.51	6.20
4	8.14	8.13	7.52	4.90	8.17	7.37	12.00
5	11.34	11.24	11.94	9.20	12.63	11.27	14.50
6	15.20	16.40	14.95	11.70	17.71	15.19	17.00
7	18.21	18.65	17.42	17.20	19.20	18.14	22.00
8	21.15	21.24	20.68	17.70	21.65	20.48	24.50
Average	12.89	13.29	12.62	10.55	13.95	12.66	16.03

\*) Research Center Standards of Oil Palm (PPKS) Medan

According to [22], the business agents of the plantation industry should conduct efficient land use through the application of good management practices in the management of oil palm plantations so that land productivity can be improved and becomes more sustainable.

Medan Land characteristics that need attention include soil fertility status and shape of the region. According to [18], in soils formed in the wet tropical climate areas (humid) such as in East Kalimantan, the weathering process occurs very intensively, and the soil generally has a deep cross-section with yellowish red color and becomes acid with high Al saturation, and its natural fertility is low. High rainfall has caused the bases not to stay longer in the soil environment and will soon be washed away from the soil. As a result, soil quickly becomes acid because most of the bases are washed away.

The materials that are left behind in the in the adsorption complex include clay and humus, most of which contain H and Al ions. As a result, soil reacting with acids with a low base saturation is formed, and the soil has high aluminum saturation, and such conditions have caused the lowness of the land suitability classification of the land cultivated. As it is known that the land suitability classification in the research areas is low i.e. S3 (Marginally Suitable), and this low grade of the land suitability classification has an impact on the technical plantation management and limit the areas to be cultivated.

**Table 5 The CPO productivity (tons/ha/year) based on the age of the plants of each plantation**

Plant Age	Productivity of CPO						Baseline of Production at the LSC of S3 *)
	Plantation 1	Plantation 2	Plantation 3	Plantation 4	Plantation 5	Average	
3	1.65	1.50	1.64	1.57	1.59	1.52	2.00
4	3.34	3.50	3.10	3.20	2.97	2.96	4.10
5	4.22	4.49	4.42	3.98	3.17	3.86	5.50
6	4.84	4.89	4.85	4.68	4.94	4.64	6.00
7	5.11	5.10	4.93	5.02	5.12	5.02	6.30
8	5.21	5.20	5.19	5.20	5.19	5.20	6.40
Average	4.06	4.11	4.02	3.94	3.83	3.87	5.05

\*S3) Research Center Standards of Oil Palm (PPKS)

Based on the research by [23], the average production potential of land of S3 classification (Marginally Suitable) was only 20.1 tones FFB/ha/year with a peak production of 26 tones of FFB/ha/year. However, the production target achieved by the plantations varied and was largely under their production potential.

In addition to land issues, the productivity of FFB and CPO is lower than the standard potential of the production based on S3 MPA S3, and it is assumed that the oil palm enterprises have not implemented the recommended standards of technical culture. Moreover, it can be proved by the data of the evaluation results which showed that there were still a lot of errors in the application of technical culture in the oil palm plantations managed in the research areas. This is consistent with the opinion of [17] who states that besides the land factor, the factor of the application of technical culture which does not follow the norms (baseline standards) also affects productivity. The research results of [4] showed that the errors in the application of technical culture at each cultivation stage resulted in different impacts and caused the decline in FFB production and low productivity of CPO produced.

## CONCLUSIONS AND SUGGESTIONS

Productivity of the FFB and CPO produced in the research areas is still low when compared to the potential standard of productivity of the land with the same land suitability classification (S3 or marginally suitable) where the FFB productivity reached 78.96% and CPO productivity reached 76.63% of the potential standard of the productivity. The low level of productivity is assumed to be caused by the level of technical culture application which has not met the recommended standards of technical culture.

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