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Study on the Production of Superior Seed Bunches of Oil Palm (*Elaeis guineensis* Jacq.) (*Case Study: Indonesian Oil Palm Research Institute-PPKS Marihat Unit)*

Yabani Yabani [1], Retna Astuti Kuswardani(*)[1], Agus Susanto[1], Saipul Sihotang[2]

[1] Doctoral Program in Agricultural Science, Medan Area University
[2] Department of Agrotechnology, Faculty Agriculture, Medan Area University
Jalan Setia Budi No. 79 B/ Jalan Sei Serayu No. 70A Medan, North Sumatra, Indonesia, Postcode 20121

***Corresponding author**: retnaastuti@staff.uma.ac.id

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Abstract

This research aims to examine the production of superior oil palm seed bunches in the PPKS Marihat Unit.Data and information collection is carried out using direct and indirect methods. Field observations carried out include: Area conditions including: topography, soil conditions, Plant conditions including: plant growth, plant population and fruit condition, Technical culture conditions: fertilization, harvesting of seed bunches. Supporting data collected includes: garden production data, rainfall and fertilization data. The research results are bSeveral factors that cause low production include: a) fertilizer amounts that are far from plant needs, given the time, type; b) plant density which is classified as less than optimal due to ganoderma attacks. The number of bunches is the result of plant physiological processes, mainly determined by the ecophysiological conditions of the plant around 24 months before harvest, where the decrease in production in the number of bunches harvested in 2020 is the result of ecophysiological conditions in the form of fertilization which is not appropriate in 2019-2020.

Keywords: *Bunches, Seeds, Oil palm, Topography, Ecophysiology*

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INTRODUCTION

The oil palm commodity (*Elaeis guineensis* Jacq.) is an important crop and really supports the nation's economy. This has an impact on the expansion of the area of oil palm plantations in Indonesia due to the high demand for vegetable oil. Quality seeds are an aspect that must be well maintained, because they will affect future growth and production results (Sihotang et al., 2022; Sihotang, 2016; Kuswardani et al., 2023). Therefore, it is hoped that increased production will be in line with the cultivation measures provided, especially oil palm plant maintenance activities.In 2020, the area of oil palm plantations was recorded to reach 16.381.959 hectare. The largest area of oil palm plantation land is on Sumatra Island 10.136.363 ha (61.88%) compared to other islands in Indonesia (Directorate General of Plantations, 2020).

Fertilization is one component of plant maintenance that has a significant influence on achieving production in the oil palm plantation business. On the other hand, fertilization is also a maintenance activity unit that requires quite a large amount of money, therefore proper fertilization from all aspects is one of the keys to success in the oil palm plantation business. In an effort to increase the accuracy of decision making in managing superior oil palm plantations and plantations, a study formula is needed that can be used to estimate the output in the form of seed bunch production from the available inputs. Seed bunch production studies need to pay attention to various aspects including genetic characteristics, plant age, technical culture and physical environmental conditions. At the Palm Oil Research Center (PPKS)-Marihat Unit, production data was used for this study. Technical cultural actions have been carried out in accordance with the SOP for management of mother trees/high-yielding seed plantations. In such conditions, the physical environment of the plant is a limiting factor in determining the high and low production of oil palm seed bunches.

Climate is one of the factors in the physical environment of plantations that cannot be controlled and plays an important role in determining the production of oil palm seed bunches. Climate change can result in changes in seed bunch production (Wicaksono et al., 2023). The magnitude of changes in production that occur due to climate influence depends on climate dynamics and/or fluctuations in each climate element in that place. The climate elements that influence the production of oil palm seed bunches are rainfall, solar radiation, air temperature, air humidity, and evapotranspiration (Wicaksono et al., 2023; Sihotang et al., 2019).

In connection with this, PPKS management feels it is necessary to conduct a study on the production of superior seed bunches to find out the causes of the low productivity of oil palm plants in the seed plantations. By knowing the causes of low plant productivity and the decline in productivity, it is hoped that technical actions can be formulated that can overcome production constraints while maximizing production achievements in 2023 and the following year.

METHODS

Research activities were carried out at the Indonesian Oil Palm Research Institute in Marihat Ulu, Pematang Siantar, North Sumatra from June to December 2023. The 2023 oil palm seed bunch productivity study was carried out through field observations, collection and analysis of supporting data. Field observations carried out include: Area conditions including: topography, soil conditions, Plant conditions including: plant growth, plant population and fruit condition, Technical culture conditions: fertilization, harvest of seed bunches.

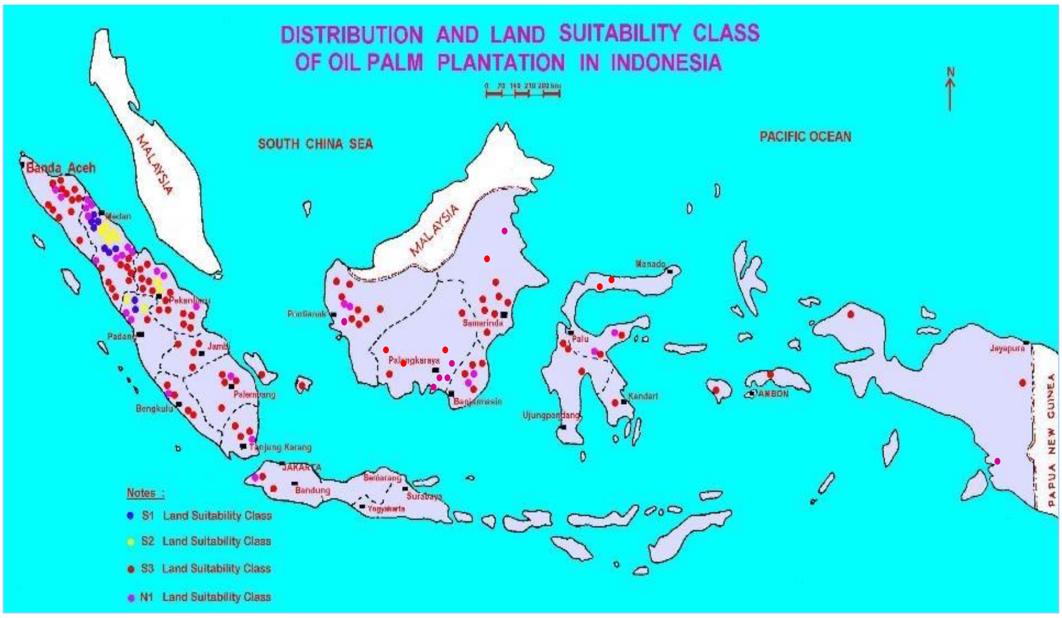


Figure 1. Distribution of land suitability classes in Indonesia (Directorate General Plantation, 2020)

Supporting data collected includes: garden production data, rainfall and fertilization data. The collected rainfall data is then used to calculate the water deficit, and to be combined with land condition data so that an overview of land classes for the Marihat Plantations Gardens area can be obtained along with production limiting factors that need attention. Production evaluation is carried out by analyzing production data obtained from the plantation, combined with fertilizer and rainfall data, and by paying attention to land conditions so that an overview of the factors that cause low production or increased seed bunch production in the following year can be obtained.

RESULTS AND DISCUSSION

General Condition of the Research Area

Indonesian Oil Palm Research Institute (PPKS) is located in Siantar sub-district, Simalungun Regency, North Sumatra Province. Geographically, Marihat unit is located at 2°52' – 2°58' North Latitude and 99°3' – 99°7' East Longitude with a height of 360-369 meters above sea level (MASL) and a distance from the coast of the Sumatra Strait of about 63 km, and about 6 km from the city of Pematangsiantar. According to the Koppen classification system, the Marihat area has a climate type Af, climate type Af is tropical rainforest climate; monthly rainfall is not less than 60 mm (2.4 in) in any month. Am as tropical monsoon climate; the driest month's rainfall is less than 60 mm (2.4 in) but exceeds 4% of annual rainfall, while according to the Oldeman classification system the climate type is D1 (BMKG Sampali, 2023).

From the Marihat Unit PPKS climatology station, climate element data can be obtained, namely rainfall, exposure time, air temperature. The condition of the station is quite good and data is recorded regularly every day. This seed garden land has a flat topography. The general condition of soil type in research area (PPKS of Marihat unit) is yellowish brown podzolic with a texture of a sandy clay top layer and a clay bottom layer and is well drained.

The Effect of Rainfall on Palm Oil Growth

In general, oil palm plants grow optimally in areas with annual rainfall between 1.750 – 3.000 mm and spread evenly throughout the year, light hours of 5 – 7 hours/day or 1.800 – 2.200 hours/year, and have an average annual air temperature of 24 – 28ºC and a minimum air temperature of not less than 15ºC (Corley & Tinker 2016). According to Siregar et al., (2005) and Pradiko et al., (2018), the climatic elements that have a dominant influence on oil palm plantations in Indonesia are rainfall, solar radiation and air temperature (if in the highlands).

Drought stress due to the dry season begins to occur in oil palm plantations if there is one parameter with the following criteria: amount of rainfall < 1.250 mm/year; water deficit > 200 mm/year; dry months (rainfall < 60 mm/month) > 3 months; and the longest period without rain (dry spell) > 20 days. Drought stress will end when the water deficit returns to 0 mm, which is indicated by rainfall of 150 mm/month or 50 mm/10 days with an increasing trend (Siregar et al., 2014).

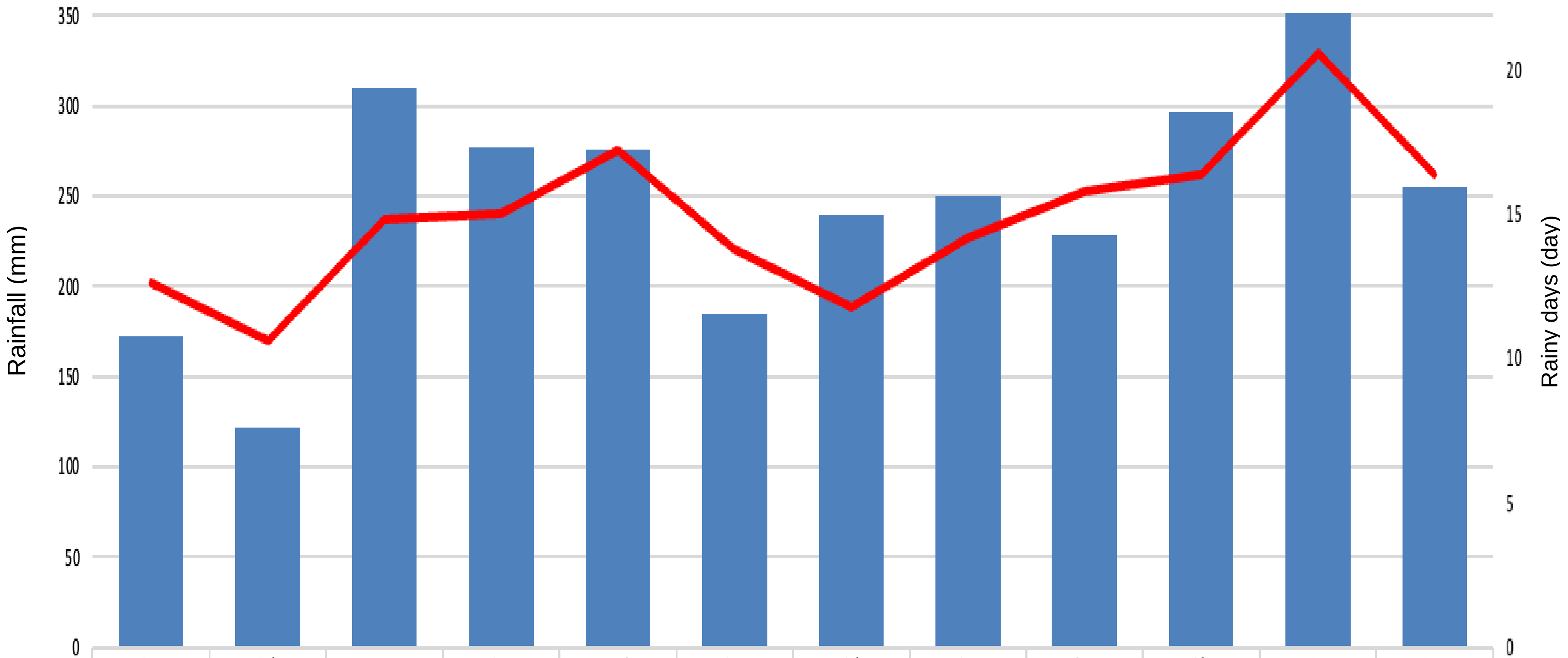
Table 1. Rainfall, rainy days, water deficit and dry months in Marihat unit gardens, 2018-2022

Year of observation	CH (mm)	HH (day)	DA (mm)	BK (month)	HTTH (days)
2018	2.947	196	35	-	64 days
2019	2.950	181	47	-	56 days
2020	2.413	152	78	1	68 days (January)
2021	3.465	175	94	1	77 days (February)
2022	3.047	192	10	-	45 days

Information: CH (rainfall), HH (rainy days), DA (water deficit), BK (dry month), HTTH (longest day without rain)

Furthermore, climatic factors have had an impact and have become a factor in reducing production in the form of longest day without rain (HTTH) where HTTH was 9 days (January) 2020. Meanwhile the water deficit was 35 mm/year (2018), 47 mm/year (2019), 78 mm/year (2020), 94 mm /year (2021), and 10 mm/year (2022), (see in Table 2). This water deficit has affected bunch production and the number of seeds produced. Rainfall also has a big influence on nutrient uptake, where the distribution of fairly high rainfall at the end of 2021 (3465 mm/year) is thought to cause a decrease in production and effectiveness of fertilizer in 2020.

The average annual rainfall in the 2018-2022 period is around 2964 mm/year with an average of 179 rainy days/year. In this period there was a water deficit of > 200 mm/year which was a limiting factor for growth that occurred every year. However, there were no reports of drought symptoms in the Marihat seed plantation. The lowest average monthly rainfall occurred in February and the highest in November (Figure 2).



	Jan	Feb	Mar	Apr	Mei	Jun	Jul	Ags	Sep	Okt	Nov	Des
CH	173	122,2	309,8	277,3	275,5	184,8	239,7	250,2	228,2	296,5	351,8	255,2
HH	12,6	10,6	14,8	15	17,2	13,8	11,8	14,2	15,8	16,4	20,6	16,4

Figure 2. Distribution of average monthly rainfall in PPKS seed plantations, 2018-2022 period (Description: CH= Rainfall; HH= Rainy days)

Corley & Tinker (2016); Yousefi *et al.,* (2021) suggests that the developmental phases of generative organs that are sensitive to drought are: (i) initiation of flower formation which occurs 42 - 44 months before physiological maturity, which can cause failure in flower formation; (ii) the formation of flower ornaments occurs 36 months before physiological maturity, which can cause the flower to be unable to continue its development; (iii) sex differentiation which occurs 17 months before physiological maturity, which causes flower development to tend to form male flowers; (iv) susceptible to flower abortion which occurs 12 months before physiological maturity, which will cause the flowers to abort; and (v) anthesis which occurs 6 months before physiological maturity, which will cause incomplete fertilization and the female flower clusters fail to reach physiological maturity. According to Siregar et al., (2007); Yabani et al., (2023) Drought also causes the ripening of the bunches to accelerate, so that the fruit is smaller, the bunches are lighter compared to bunches in the rainy season.

Table 2. Water deficit criteria and its impact on the growth and production of oil palm plants

Stadia	Water deficit (mm/yr)	Symptoms of oil palm growth	Production decline (%)
I	<200	Not that influential yet	0-10
II	200 -300	In TBM and TM, 3-4 young leaves are collected and do not open In TM, 1-4 midribs of old leaves are broken (called sengkleh)	10-20
III	300-400	In TBM and TM, 4-5 young leaves do not open In TM, 8-12 old leaf midribs break and dry out	20-30
IV	400-500	In TBM and TM, 4-5 young leaves gather together and do not open In TM, 12-16 old leaf midribs break and dry out	30-40
V	>500	In TBM and TM, young and old leaves are like stage IV In TM and TBM, the pupus bends and can eventually break	>40

Description code TM= Mature; TBM= Immature, Source: (Siregar et al., 2014)

Proper implementation of fertilization INT

Fertilization should be carried out according to recommendations (5 T = exact type, dose, time, method and sequence of application). Fertilization must be in accordance with the needs of oil palm plants. If fertilization is done correctly, optimal productivity will be achieved. Inaccuracy of fertilization causes low effectiveness of fertilization. Provision of fertilizer should be done on time, while the dosage of fertilizer in the field should be based on plant needs. The condition of tree plates where weed control is delayed due to delays in herbicide availability must be cleaned immediately before fertilizing. Fertilizer that has been received by the garden should be applied immediately to avoid delays in fertilizing.

The realization of fertilization carried out in the Marihat seed garden in 2018-2022 does not always comply with the recommended dose as well as the application time. In 2018 and 2022 two applications were made, whereas in 2019 only the first semester, 2020 and 2021 were made one or two applications per semester but not according to the recommended dose. Meanwhile, in 2022 there can be two applications.

The main problem of decreased production in 2020, apart from water deficits and dry months, was also exacerbated by fertilization not being carried out. This is in accordance with the results of research by Sidhu et al, (2014), that the effect of not applying it will have an impact on reducing leaf nutrient content and reducing production in 20-30 The month after application can reach 3.9 tons of FFB/year/ha, which is lower than when fertilizer is applied normally. Apart from that, fertilization that is not implemented in the nth year can cause a decrease in productivity in the n+1 and n+2 years. respectively as much as 16%-23% and 10%-16% compared to productivity in the nth year. This is in accordance with the condition of the Marihat seed garden, where fertilization did not go well in Period II 2019 and Period I 2020.

Table 3. Realization of fertilization of Marihat main trees for the 2018-2022 period

Year				**Period I (Kg)**				
	Urea	TSP/ISP-24	MOP	DOL	Boron	NPK	Bionensis	Total
2018	1.97	2.25	1.25	1.50	0.10	-	-	7.07
2019	1.25	1.25	1.25	1.50	0.10	-	-	5.35
2020	-	-	--	1.25	0.05	3.50	1.50	6.30
2021	1.,25	1.00	1.25	1.25	-	2.50	-	7.25
2022	1.,25	1.00	1.25	1.00	0.075	2.25	-	6.75
Year				**Period II (Kg)**				
2018	1.00	0.75	1.00	1.25	-	-	4.00	11.07
2019	-	-	-	-	-	-	0.00	5.35
2020	-	-	-	1.25	-	2.50	3.75	10.05
2021	-	-	-	-	-	-	0.00	7.25
2022	1.25	1.00	1.50	1.25	0.075	2.25	7.25	14.00

About 46% of net assimilate production is allocated to vegetative growth and the remaining 54% to generative growth. The main priority for assimilate allocation is for vegetative, after vegetative needs are met then assimilate is allocated to generative growth. According to Corley et al., (2003), around 45-50% of surface biomass production (above ground biomass) is allocated for generative growth, assimilate for generative will be allocated if assimilate for vegetative needs is met (vegetative as a priority).

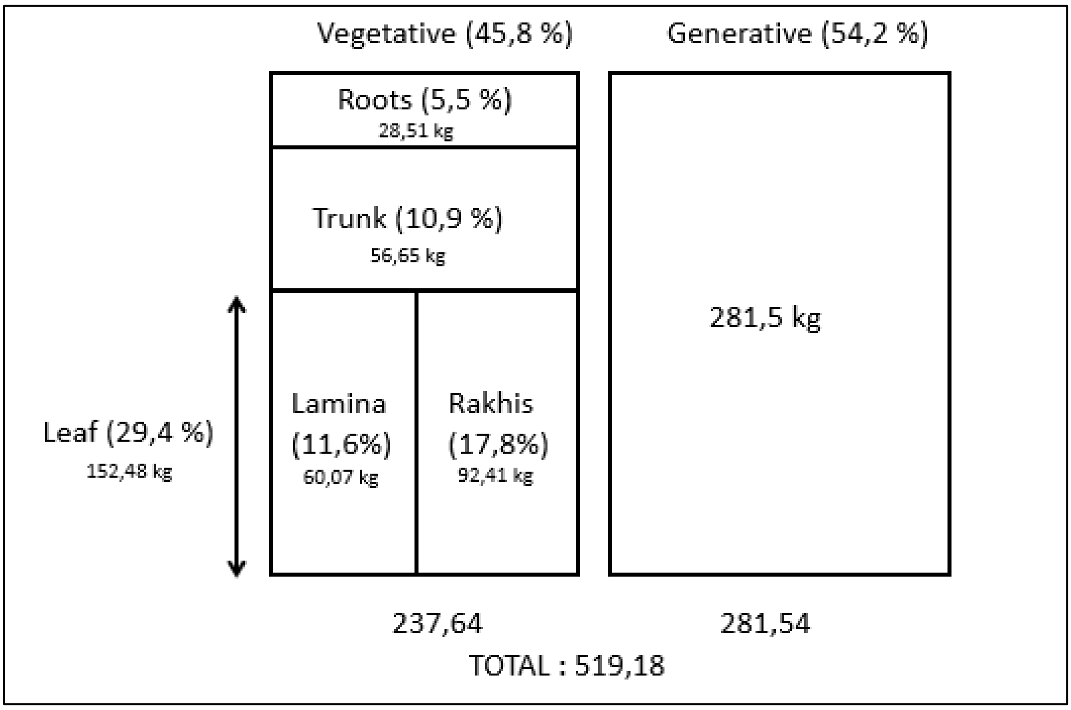


Figure 3. Net assimilate partition diagram (kg CH2O/tree/year)

Seed bunch productivity

Seed bunch productivity and number of seeds tend to increase in 2021-2022, then decrease in the 2018-2020 period (Figure 3). This decrease in production was more due to the acquisition of the number of seed bunches and the unstable seed average. Reduction in the number of mother trees due to Ganoderma disease.

Table 4. Development of number of seed bunches, number of seeds and average number of seeds for the 2018-2022 period

Information	2018	2019	2020	2021	2022
Number of seed bunches (fruit)	14.342	12.153	10.736	12.965	14.592
Number of seeds (grains)	17.897.180	15.414.516	15.902.759	17.744.910	20.772.855
Average number of seeds (grains)	1.276	1.287	1.491	1.372	1.447

The number of bunches harvested is the result of a long process, most of which occurs within the oil palm plant itself. Assuming there are no losses during harvest, the number of bunches produced by the plant is the result of a long process, especially determined around 14-24 months before harvest, which is the sex determination phase (determining male or female flowers). Agroclimatological factors and plant physiology will determine the formation of female flowers. Ecophysiological conditions that are not optimal in critical phases will disrupt the formation of female flowers (red line in Figure 4). If the female flower clusters have emerged, the number of clusters will not decrease unless abortion occurs due to the long dry climate.

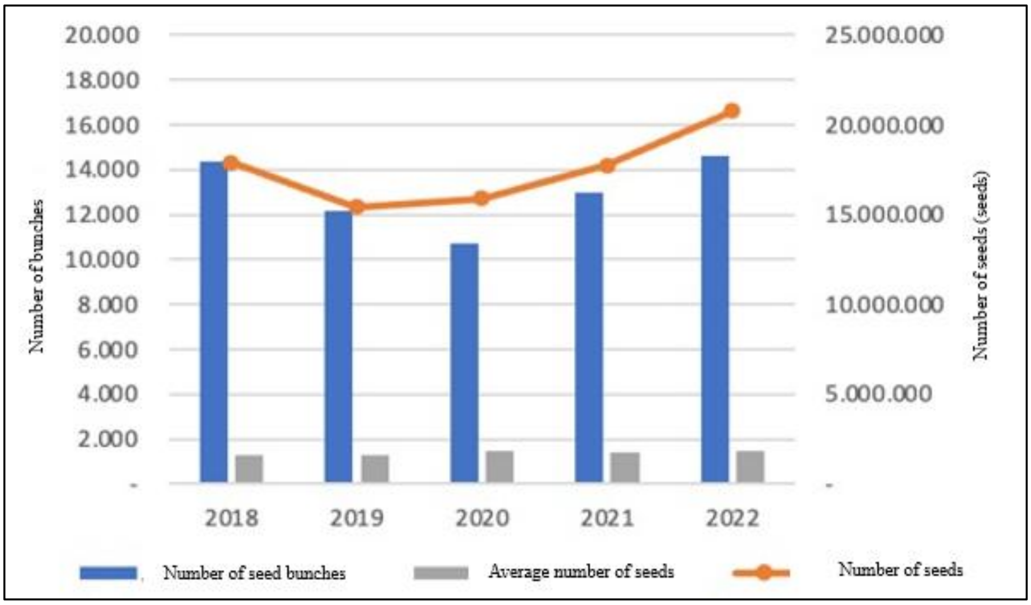


Figure 4. Development of number of seed bunches, number of seeds and average number of seeds for the 2018-2022 period

Therefore, to find out the cause of the reduction in the number of bunchesseeds (10.736 bunches, with an average of 1.491 seeds) sharp in 2020, we have to study non-optimal ecophysiological factors or conditions around 24 months or 2 years before harvest in 2020, which means 2018. Non-optimal ecophysiological conditions What needs to be paid attention to in 2018 can be climate conditions, fertilizer treatment, canopy management (number of fronds), and other things that will determine bunch production. However, the available data that we can analyze so far is quite complete, including rainfall data and fertilization data, while there are no specific records for technical culture treatment, although in the discussion it was mentioned that in 2018 there were problems related to plant care.

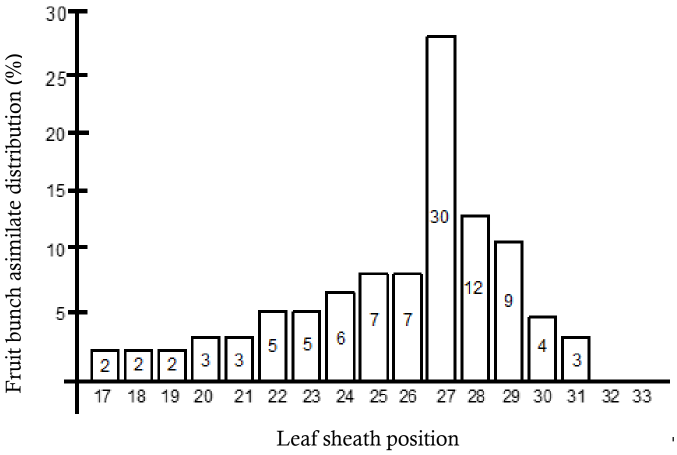


Figure 6. Position Of Palm Farmers

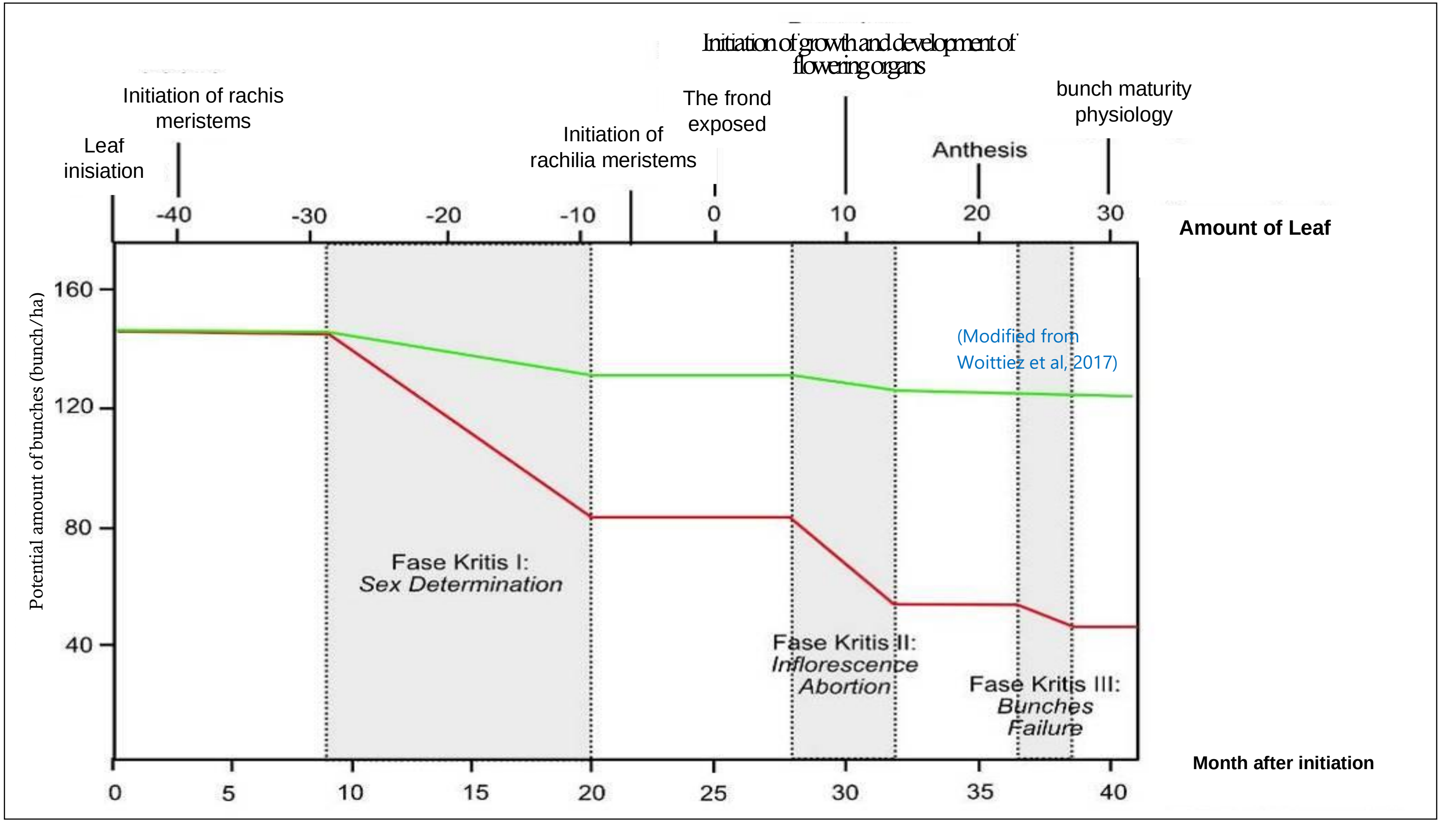


Figure 5. Graph of the development phases of oil palm fruit bunches

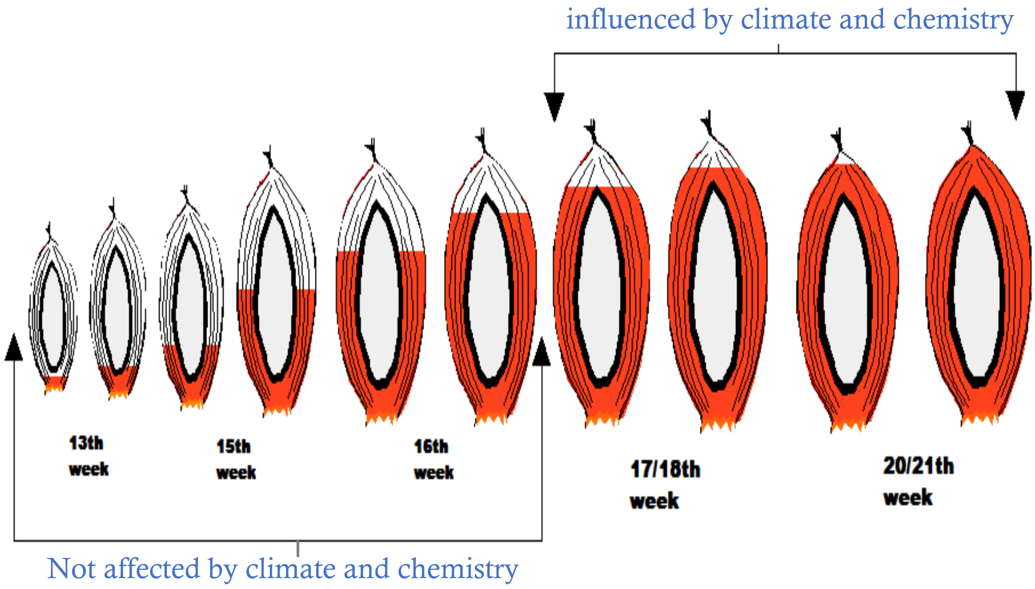


Figure 7. Development of oil palm fruit composition after the receptive period (PPKS, 2020)

The development of the mesocarp of oil palm fruit is divided into five phases. Phase I occurs between 30 and 60 days after pollination (HSP) which is characterized by anticlinal cell division and cell enlargement with an initial increase in fruit size and weight. Phase II between 60 and 100 DAP is a transition period characterized by fresh weight accumulation and high amounts of indole-3-acetic acid (IAA). Phase III between 100 and 120 DAP is the end of the transition period, seen by decreasing concentrations of auxin, cytokinin and gibberellin. Phase IV is the initial phase of ripening which is seen by an increase in mesocarp fresh weight and lipid accumulation seen at 120 DAP. In this phase, lipids can reach 2 g fruit-1 and carotene accumulation begins to occur. Phase V is a ripening phase which is characterized by increasing concentrations of the hormones ABA and ethylene (Tranbarger et al., 2011).

Improvement of good technical culture

Weed control, both in tree disks and in plant bushes, must be carried out according to rotation and with an environmentally friendly perspective. Avoid continuous total (blanket) weed control. Implement good frond management by keeping fresh fronds for plants aged ≤ 8 years as many as 48-56 fronds/tree, aged > 8 years as many as 40-48 fronds/tree. The arrangement of the fronds neatly forms a U Shape, especially in sloping areas.

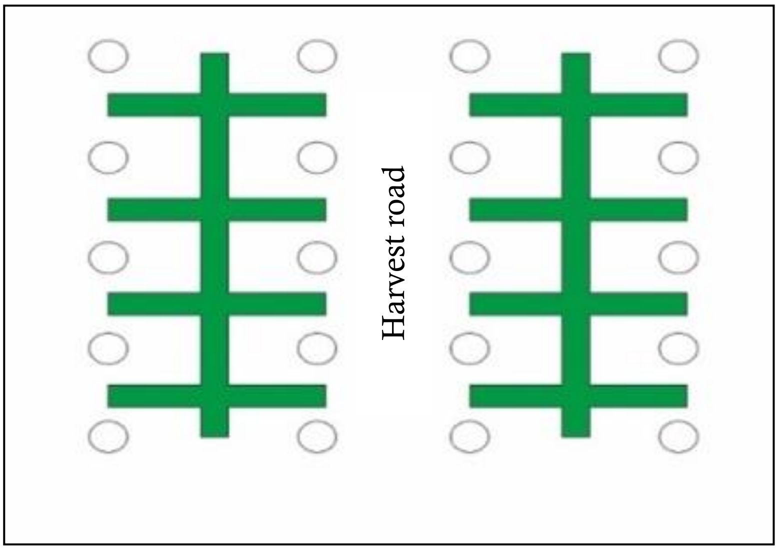


Figure 8. Schematic of arranging shoot-grown fronds using a U shape system for flat-wavy areas

There are several benefits obtained by arranging the "U" fronds, including: (1) Soil and water conservation, by evenly arranging the fronds, more of the ground surface will be covered. So that the impact of raindrops reaching the surface which can destroy soil aggregates is also reduced. The volume of water that will enter the soil will increase, which means surface flow will decrease so that erosion of the topsoil will also decrease. Of course, the greater the number of healthy roots, the better the absorption of nutrients (fertilizer). and (2). Helps suppress weed growth, which means saving on weed control costs too.

CONCLUSION

Based on the results of the study and analysis of data obtained from the seed garden, it can be concluded as follows:

a) The average number of seeds obtained in 2022 was 1,447 per bunch, lower than the seed obtained in 2020 of 1,491 bunches. This step can of course be improved by applying proper fertilizer and implementing BMP (Best Management Practice).
b) Several factors that cause low production include: a) fertilizer amounts that are far from plant needs, given the time, type; b) plant density that is classified as less than optimal due to ganoderma attacks,
c) The number of bunches is the result of plant physiological processes, mainly determined by the ecophysiological conditions of the plant around 24 months before harvest, where the decrease in production in the number of bunches harvested in 2020 was the result of ecophysiological conditions in the form of inappropriate fertilization in 2019-2020.

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