Implication of Climate Change on Oil Palm Plantation in Higher Altitude (Case of North Sumatra Province)[1]

Hasril Hasan Siregar, Edy Sigit Sutarta and Nuzul Hijri Darlan

Indonesian Oil Palm Research Institute (IOPRI)
Jl. Brigjen Katamso 51, Medan 20158 Indonesia
E-mail : admin@iopri.org

Abstract

It is estimated that the climate change has an important implication and serious threat, such as decrease of plant productivity, decrease of water source quality and quantity, increase of sea level, and increase of certain disease like dengue fever. Implication of climate change on oil palm plantation in Indonesia generally not much known, it could be threat that need attention or maybe an opportunity. At one side, climate change caused the rainy season more wet and dry season more dry. At another side, climate change that caused the temperature increased, could made an extension of oil palm plantation in higher altitude become possible. This paper describes climate change in North Sumatra Province and its implication to extension of oil palm plantation, and also response of oil palm productivity in higher altitude.

Keywords : climate change, oil palm, temperature, altitude, North Sumatra

Introduction

Climate change is a global phenomenon that mainly forced by human activity, especially that related to the use of fossil fuel and land use change. The activity will produce gases which are increase by the time at the atmosphere. The main gases are carbon dioxide (CO_2), methane (CH_4), and nitrous dioxide (N_2O). These gases called green house gases which has character like glass that forward the short-wave radiation or sunlight, absorb and reflect the long-wave radiation or back-radiation from earth which is hot that caused earth temperature increased. Climate change caused the atmosphere condition change too, especially temperature and rain distribution which made wide implication to several human life sector at a long period of time.

Implication of the climate change that happened in Indonesia nowadays are the higher air temperature, drier drought at dry season, and higher floods intensity at rainy

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season. These are caused by the ability of the green house gases (GHG) emissions which accelerate radiation transmission from the sun to earth and become barrier for some radiation that leave the earth. When the GHG concentration increased, radiation from the earth will obstructed that made earth temperature increased. The best estimation of temperature increase at this 21st century is from General Circulation Models (GCMs), which is 2.5 – 5.5 ^{0}C follow with the increase of hydrology circulation rate equal to 5 – 15 %, or as the effect of global climate change in Indonesia, made the rainfall increase especially at rainy season equal to 15 % for every 1 ^{0}C temperature increase (IPCC, 1996).

Generally, many people in Indonesia estimate that the climate change has an important implication and serious threat, such as decrease of extensive agriculture farm, decrease of plant productivity, change of the forest use and function, decrease of water source quality and quantity, increase of sea level that caused many coastal area sank and coastal area function change, and increase of certain disease like dengue fever.

Implication of climate change on oil palm plantation in Indonesia generally not much known, it could be a threat that need attention or an opportunity for the development of agriculture. When the climate change happened, it would made some land that formerly unsuitable for oil palm became suitable, or on the contrary. At one side, climate change that caused the rainy season more wet and the dry season more dry can decrease oil palm productivity. At another side, climate change that caused the temperature increase, could made an extension of oil palm plantation in higher altitude (>600 meter above sea level (m asl) become possible.

This paper present the climate change that happened in North Sumatra Province, and also its implication to the extension of oil palm plantation and also response of oil palm productivity in higher altitude (>600 m asl).

Climate Change in North Sumatra Province

The climate change and global warming has been proven happened in North Sumatra Province, even in Indonesia. The phenomenon like the long and often drought,

and also an often flood that caused by rainfall above normal. Indonesian Meteorological and Geophysical Service (Badan Meteorologi dan Geofisika, BMG) had data or evidence about the presence of global warming. Several sample observation station showed that there is air temperature increase in the morning (Hutapea and Wiyoso, 2003). The same finding was shown from the data of air temperature collected in several altitudes in North Sumatra during 1970 – 2005 period. The largest increment of minimum air temperature happened at the altitude about 850 m asl (Table 1).

Table 1. Change of temperature at some altitude in North Sumatra, period 1970-2005 (Slope Regression Line Analysis (^{o}C/decade))

Parameter	Increment of temperature per decade (^{o}C/10 years)		
	Medan (27 m asl)	Marihat (369 m asl)	Bah Butong (850 m asl)
- Mean annual temperature	0.46	0.31	0.47
- Minimum annual temperature	0.55	0.25	0.65
- Maximum annual temperature	0.33	0.20	0.28

Figure 1. Time series of mean annual temperature in North Sumatra (Source: BMG; Hutapea dan Wiyoso, 2003)

Based on perception result from several BMG station in North Sumatra Province, Hutapea and Wiyoso (2003) explained that beside a tend to air temperature increase, there is also a tend to rainfall increase especially at rainy season. Figure 1 showed that

temperature trend in North Sumatra generally indicate a significant increase which are 0.5 – 1 ^{0}C for 30 years (period 1974 – 2002). This condition will caused the increase of air ability to intercept water vapor, which made the rainfall tend to increase and fluctuate during rainy season. This condition also caused the rainy season more wet and dry season more dry, that would made an increase of flood and dryness threat.

Table 2. Periodically changes of climate parameter at 1971-2005 at some altitude in North Sumatra

No.	Climate parameter	Location (altitude, m asl)		
		Medan (27 m asl)	Marihat (369 m asl)	Bah Butong (850 m asl)
1.	Mean monthly temperature (˚C)			
	- period 1971 – 1980	24.8 – 27.3	23.3 – 25.2	21.3 – 22.6
	- period 1981 – 1990	25.3 – 28.2	23.6 – 25.7	22.5 – 23.2
	- period 1991 – 2005	24.9 – 28.4	24.1 – 26.3	22.4 – 24.0
2.	Minimum monthly temperature (˚C)			
	- period 1971 – 1980	21.0 – 23.0	18.6 – 20.7	16.7 – 17.7
	- period 1981 – 1990	21.1 – 24.4	18.6 – 20.8	17.1 – 18.5
	- period 1991 – 2005	22.5 – 24.5	19.9 – 21.1	18.0 – 19.5
3.	Maximum monthly temperature (˚C)			
	- period 1971 – 1980	30.0 – 32.9	28.2 – 32.0	26.8 – 28.1
	- period 1981 – 1990	30.0 – 34.4	27.9 – 31.7	27.6 – 28.1
	- period 1991 – 2005	30.1 – 34.4	28.1 – 32.3	27.7 – 28.9
4.	Sunshine duration (hours/day)			
	- period 1971 – 1980	2.7 – 7.0	3.0 – 7.2	–
	- period 1981 – 1990	2.8 – 7.1	3.1 – 7.8	1.4 – 6.9
	- period 1991 – 2005	2.7 – 7.2	2.4 – 7.2	3.0 – 7.0
5.	Rainfall (mm/year)			
	- period 1971 – 1980	1755 – 2161	2017 – 3275	–
	- period 1981 – 1990	1838 – 2808	2564 – 3738	2180 – 3177
	- period 1991 – 2005	1457 – 2258	2447 – 3653	1637 – 4481
6.	Dry month (month/year)			
	- period 1971 – 1980	1 – 3	0 – 2	–
	- period 1981 – 1990	0 – 3	0 – 1	0 – 2
	- period 1991 – 2005	1 – 3	0	0 – 2

The trend or time series of annual mean, minimum, and maximum air temperature were also shown from exploration of historical data during 1970 – 2005 period (Figure 2, 3, and 4). Those figures showed that the drastic increase was at minimum temperature that caused the mean temperature also increase drastically, which is shown that the mean morning temperature has increased drastic enough, meanwhile the maximum temperature showed a slow increase.

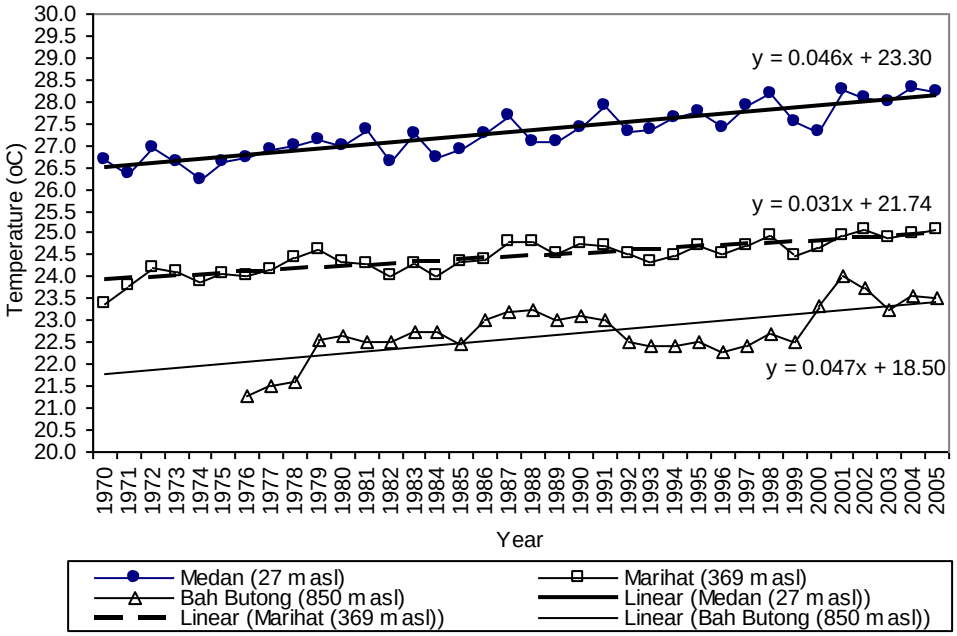

Figure 2. Time series of mean annual temperature at some altitude in North Sumatra

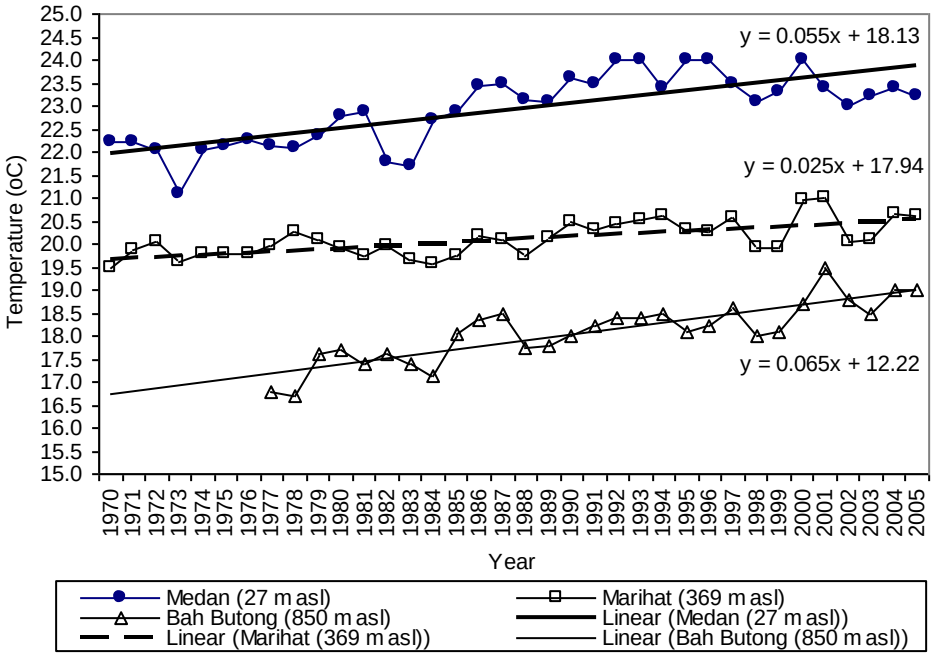

Figure 3. Time series of minimum annual temperature at some altitude in North Sumatra

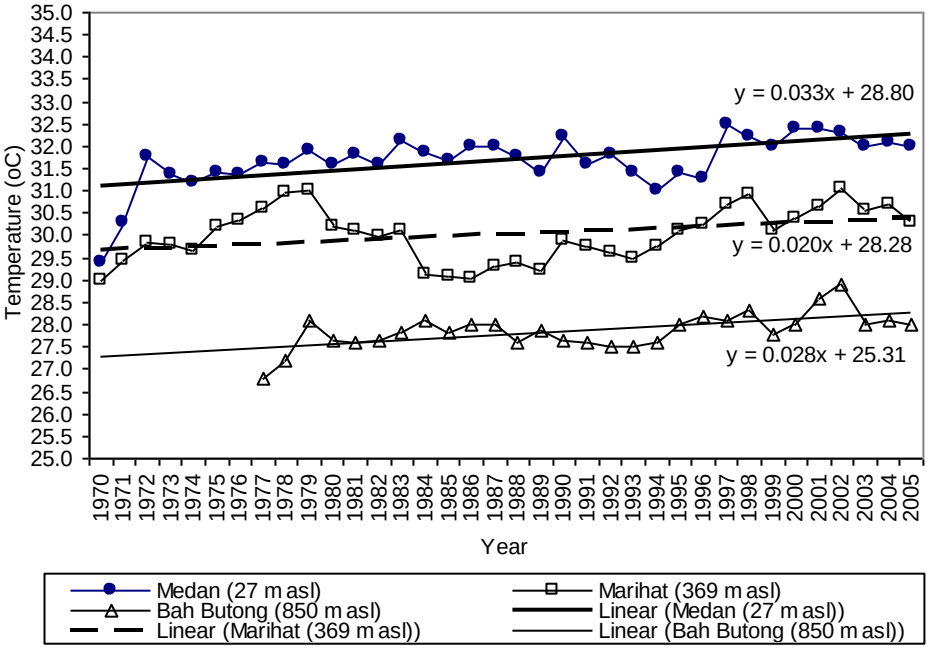

Figure 4. Time series of maximum annual temperature at some altitude in North Sumatra

Implication of the fluctuation of rainfall was a longer drought which caused water intake to the ground will decreases, meanwhile barrage volume and river flow will be influenced. Despitefully on rainy season, rainfall became higher. Other implication of the climate change was the change of cultivation system which made farmer adapted their cultivation due to that change. This change also could affect the strategy problem on maintaining food safety, because there is always threat of dryness and flood.

By the temperature increase, possibility that some of ice at pole would melting which caused the increase of sea level, so that the agriculture, resident settlement, and ecosystem around the coast will be threatened. The increase of sea level also could forced the water go forward to continent. The 10 cm increase of sea level would force the water as far as 1 km to the higher continent.

Extension of Oil Palm Plantation in Higher Altitude

Extension of oil palm plantation in higher altitude (> 600 m asl) is possible through 3 approaches, i.e. physical environmental factor, plant material genetic factor, and technical cultivation. The approach of physical environmental factor (soil and climate) was using recent superior plant material due to oil palm grow condition, which is the main limited factor in higher altitude is a minimum air temperature that < 18 ^{0}C. The approach of plant material genetic factor use the cold tolerant plant material or altitude adapted oil palm hybrid (Blaak and Sterling, 1996; Chapman, Escobar and Griffee, 2003; Alvarado and Sterling, 2005). Meanwhile the technical cultivation approach due to an adjustment of oil palm technical cultivation in higher altitude like plant spacing arrangement that between 110 – 120 palm/ha.

Minimum temperature is the main limiting factor for oil palm growth in high altitude, due to minimum temperature in that altitude is < 18 ^{0}C, while oil palm requires minimum temperature > 18 ^{0}C. Analyze report about climate change as an impact from the global warming in higher altitude (Table 1, Figure 2, 3, and 4). Case of North Sumatra showed that during the last 30 years, there was a annual mean air temperature increased between 0.31 – 0.47 ^{0}C per 10 years, annual minimum air temperature increased between 0.25 – 0.65 ^{0}C per 10 years, and annual maximum air temperature increased between 0.20 – 0.33 ^{0}C per 10 years. All the air temperature parameters tend to increase, also followed by the increase of sunshine and rainfall parameter, but tend to not consistence (Table 2).

The increase of annual minimum air temperature became ≥ 18 ^{0}C after 1990 at 850 m asl has an implication to the extension of oil palm plantation in higher altitude (600 – 850 m asl) that become possible. Based on analyze report of main limited factor in higher altitude was annual minimum air temperature that < 18 ^{0}C and other oil palm grow condition such as sunshine intensity that ≥ 4 hours/day, annual rainfall that > 2500 mm/year, and total dry month that < 3 months/year (Abraham, 1991 and Adiwiganda *et al*., 1999). Therefore based on physical environmental factor, it was possible to extend oil palm plantation into higher altitude until 850 m asl.

Monthly minimum air temperature is about < 18 ^{0}C possibly happened fluctuate at December and January. This could disturb oil palm metabolism and inflorescences process that caused "low air temperature stress". Effect of the low air temperature stress could analogue with "drought stress" such as (i) increase of abortion, (ii) failed or rotten bunch, (iii) fluctuated and low productivity, and (iv) long inflorescences (8 – 9 months).

Development of oil palm plantation on high altitude could be conducted by using cold tolerant plant material. This plant material could analogue with the drought tolerant plant material. The characters of the cold tolerant plant material are (i) smaller crown but larger leaf area index, (ii) high amount of bunches. Plant material from Indonesian Oil Palm Research Institute (IOPRI) whose had those characters are D x P Lame (Purba, A. R., 2005. Personal communication).

Productivity of D x P Yangambi (IOPRI plant material) in higher altitude tend to be lower than standard productivity of marginal land at 0-600 m asl (Figure 5 and 6). Some bunch quality components of 9 years old oil palm showed quite similar in term of mesocarp to fruit (83.63-84.46%), oil to bunch (31.34-31.67%), and oil extraction ratio (26.79-27.08%) compared to those of low altitude (Figure 7).

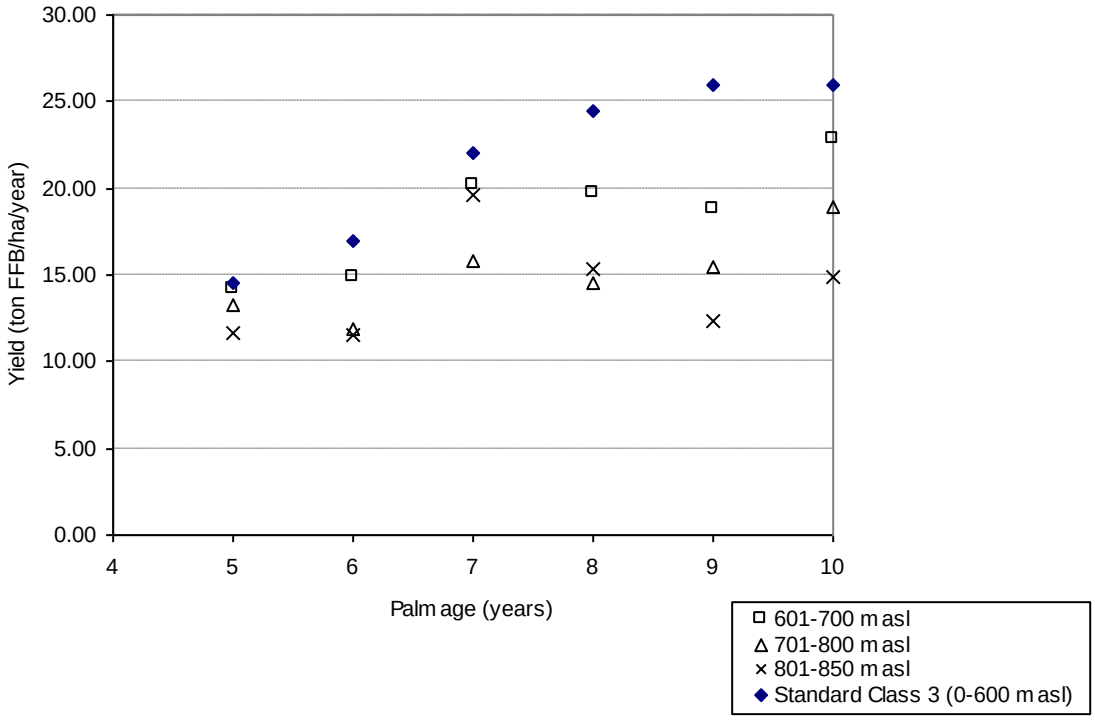

Figure 5. Scatter plot of oil palm yield, palm age 5-10 years after planting at 3 group altitude

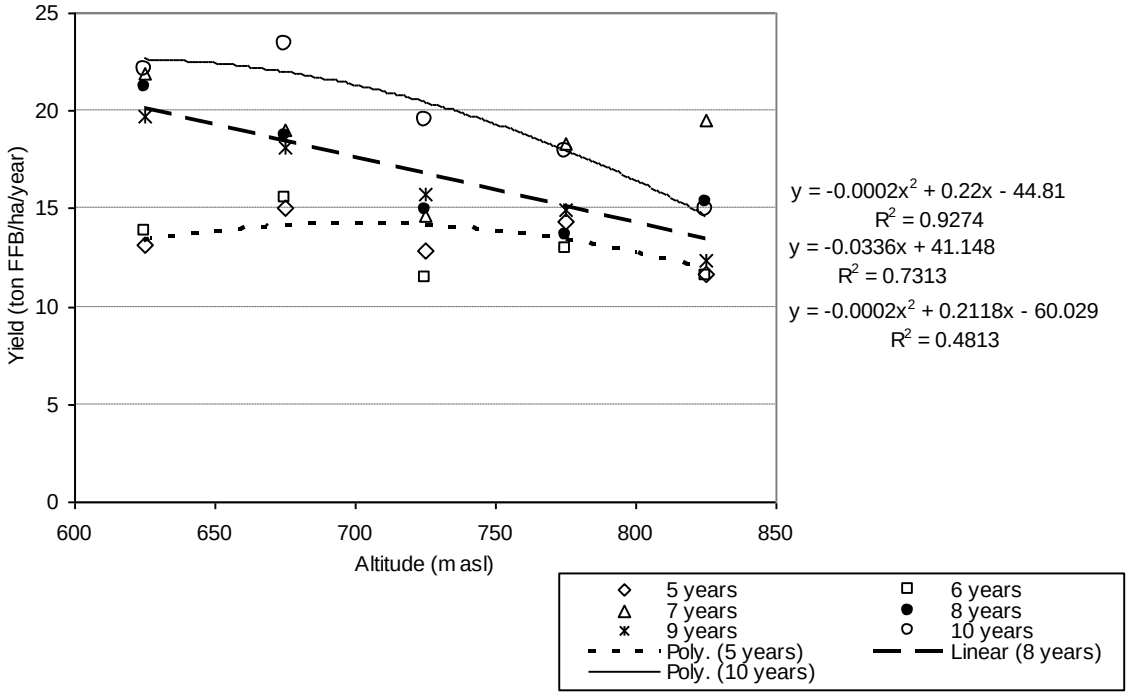

Figure 6. Relation of altitude with oil palm yield, palm age 5-10 years after planting

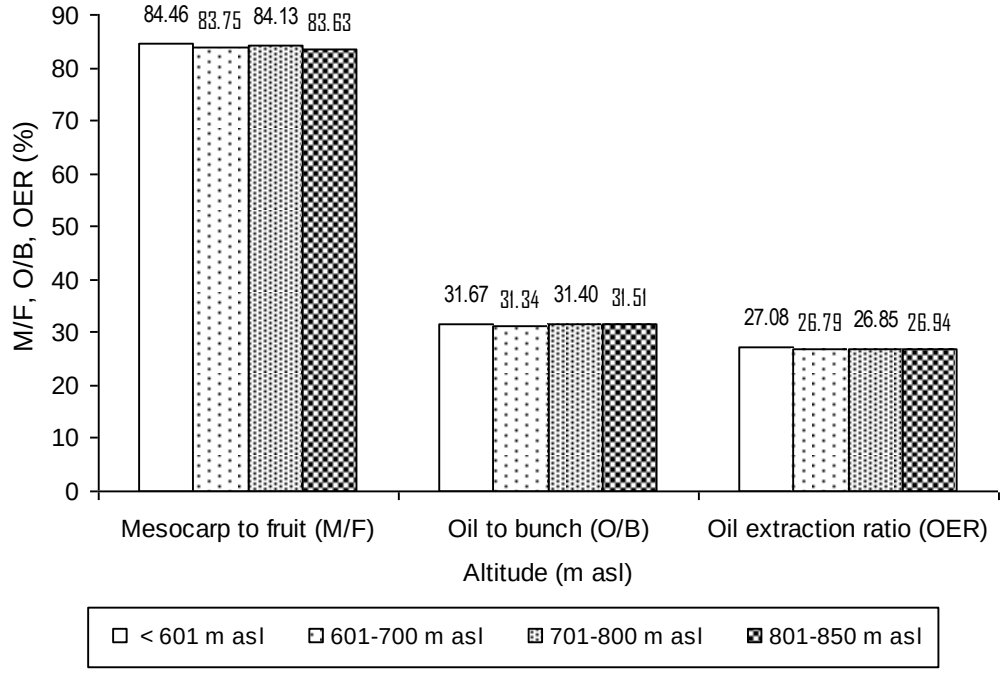

Figure 7. Comparisons of mean of some bunch quality components, 9 years after planting in higher altitude in Bah Birung Ulu, North Sumatra

Until 2005, total area of oil palm plantation in high altitude in North Sumatra was 3857 hectares, increased from 443 hectares in 1996 (Table 3). Most likely this condition becomes an important consideration to develop oil palm plantation at high altitude in other provinces.

Table 3. Extension of oil palm plantation in higher altitude in North Sumatra

No.	Location	Planting year	Area (hectares)
1.	Bah Birung Ulu	1996	443
		2004	91
		2005	1294
2.	Bah Butong	2005	344
3.	Marjandi	2005	1477
4.	Batang Toru	2005	208
	Total		3857

Conclusions

Implication of climate change on oil palm plantation would made some land that formerly unsuitable for oil palm became suitable, or on the contrary. Climate change that caused the temperature increase, could made an extension of oil palm plantation in higher altitude (600 – 850 m asl). In North Sumatra, the increase of annual minimum air temperature became $\geq 18\ ^{0}C$ after 1990 at 850 m asl that implicated to extension of oil palm plantation in higher altitude. Until 2005, total area of oil palm plantation extension in higher altitude in North Sumatra was 3857 hectares.

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