Oil Palm Bulletin 74 (May 2017) p. 1-6

The Impact of *El Niño* and *La Niña* on Malaysian Palm Oil Industry

Nur Nadia Kamil* and Syuhadatul Fatimah Omar*

ABSTRACT

El Niño *and* La Niña *are two complex weather patterns that result from variations in the ocean temperatures of the equatorial Pacific. Being close to the equatorial Pacific, the occurrence of the so-called* El Niño-*Southern Oscillation (ENSO) events has a notable impact on Malaysian weather. The wind circulation of the ENSO influences the precipitation in Malaysia. The extreme changes in rainfall level either below or above the average does significantly affect the productivity of the Malaysian main agriculture commodity namely palm oil. The reduction in rainfall amount creates stress during the development of oil palm fruit bunches and hence reduces the FFB yield of the palms. On the other hand, higher than average rainfall also has a negative effect on the oil palms and reduces the oil production. The occurrence of these two events is seen to affect CPO prices. However, our analysis suggested that there was no significant relationship between rainfall and CPO prices, but CPO production does.*

ABSTRAK

El Niño *dan* La Niña *adalah dua corak cuaca yang kompleks disebabkan oleh perubahan suhu lautan Pasifik di khatulistiwa. Terletak hampir dengan khatulistiwa lautan Pasifik, corak cuaca di Malaysia dipengaruhi oleh peristiwa yang dikenali sebagai* El Niño *dan* Ayunan Selatan *(ENSO). Peredaran angin disebabkan oleh kejadian ENSO mempengaruhi taburan hujan di Malaysia. Perubahan dalam taburan hujan yang melampau sama ada di bawah atau di atas paras purata taburan hujan memberi kesan ketara kepada produktiviti komoditi pertanian utama Malaysia iaitu minyak sawit. Pengurangan jumlah hujan mewujudkan tekanan semasa terhadap proses perkembangan tandan buah sawit dan dengan itu mengurangkan hasil buah tandan segar (BTS). Sebaliknya, hujan yang lebih tinggi daripada purata juga mempunyai kesan negatif ke atas tanaman sawit dan mengurangkan pengeluaran minyak. Secara amnya, taburan hujan yang terlalu rendah dan terlalu tinggi dilihat memberi kesan kepada pergerakan harga minyak sawit mentah (CPO). Walau bagaimanapun, analisis kami mencadangkan bahawa tidak terdapat hubungan yang signifikan di antara taburan hujan dan pergerakan harga minyak sawit mentah, tetapi perubahan dalam taburan hujan didapati mempengaruhi kadar pengeluaran CPO.*

Keywords: *El Niño, La Niña*, ENSO, FFB yield, CPO prices.

INTRODUCTION

Palm oil is an edible vegetable oil derived from the mesocarp (the pulp) of the oil palm fruitlets. Oil palm is the most efficient oilseed crop in the world and palm oil is the world's leading vegetable oil. In 2015, the total world palm oil production was 62.79 million tonnes, accounting for 30.6% of the world production of major oils and fats (Malaysian Palm Oil Board, 2016). The three largest producers of palm oil are Indonesia, Malaysia, and Thailand, where the palm oil output from Malaysia in 2015 was 19.96 million tonnes or 31.8% of the world's total palm oil production. Palm oil is an important commodity, generating a significant amount of revenue for the Malaysian economy. According to the Malaysian Department of Statistics, the export earnings from palm oil in 2015 totaled RM 40.1 billion, equivalent to 5.1% of Malaysia's total exports (Malaysia External Trade Development Corporation, 2016).

Palm oil is widely used in both food and non-food industries such as for margarines, shortenings, soap production, detergents, cosmetics as well as for biofuel. Owing to its wide applications, the global demand for palm oil is expected to remain strong. This is also underpinned by the increasing world population which is projected to increase to 9.7 billion by 2050 from the current of 7.3 billion (The United Nation, 2016). To cater for the future demand, the Malaysian government has implemented various strategies to ensure a sustainable supply of palm oil such as providing the best quality planting materials, giving incentives for replanting of the oil palm trees, and promoting good agricultural practices. In spite of these efforts, the supply of palm oil at certain times may be disrupted due to the weather. Adverse weather conditions which are

* Malaysian Palm Oil Board,
6, Persiaran Institusi, Bandar Baru Bangi,
43000 Kajang, Selangor, Malaysia.
E-mail: nadiakamil@mpob.gov.my

associated with the occurrence of *El Niño* and *La Niña* is said to be one of the reasons for the decline in palm oil production and this indirectly influences the crude palm oil prices. Hence, this paper aims to give a review on how *El Niño* and *La Niña* influence the Malaysian weather pattern and how it affects palm oil production. Additionally, this paper will also examine the relationship between the changes in weather and crude palm oil prices.

What is *El Niño* and *La Niña*?

Weather always is the key element in agriculture. The difference between weather and climate is a measure of time. Weather is the condition of the atmosphere over a short time of period (weeks, days, hours and minutes), while climate is the average of that weather over a longer period of time. Located within the Asia Pacific, Malaysia, Indonesia, and Thailand are exposed to a range of climate conditions and extreme events. The region's climate is also influenced by the variability associated with the *El Niño*-Southern Oscillation (ENSO) which gives rise to cyclic droughts and extreme sea levels. The climate variability is driven by changes in the circulation of winds, rainfall and ocean surface temperatures that led to the development of *El Niño* and *La Niña* events.

El Niño means 'The Little Boy' or 'Christ child' in Spanish. It was recognised as the appearance of unusually warm water in the Pacific Ocean (National Oceanic and Atmospheric Administration (NOAA), 2016). *El Niño* is characterised by unusually warm ocean temperatures in the Equatorial Pacific. Meanwhile, the opposite of *El Niño* is called *La Niña*, which is characterised by unusually cold ocean temperatures in the Equatorial Pacific.

El Niño and *La Niña* are the opposite phases of the *El Niño*-Southern Oscillation (ENSO) cycle, a scientific term that describes the fluctuations in temperature between the ocean and atmosphere in the east-central equatorial Pacific. Under the normal condition in Tropical Pacific, there is a consistent wind called trade winds, blowing from east to west. These winds push warm water near the surface and slowly warm water accumulated on the western side of the ocean near Asia and Australasia. On the other side of the ocean, near South and Central America, as the warmer water get pushed away from the coast, it is replaced by cold water from deep down in the ocean and this process is called upwelling. The upwelling process creates a temperature difference across the tropical pacific, with warmer water accumulates in the west (Asia and Australasia) and cooler water in the east (South and Central America). Warmer water adds extra heat to the air which causes the air to rise rapidly and this rising air creates a scenario of more unsettled weather with more clouds and rainfall. The rising air in the west sets up an atmospheric circulation across this part the world with warm moisture rising on the western Pacific Ocean and cooler dry air descending on the other side. This circulation reinforces the easterly winds so that this part of the world sits in a self-perpetuating state until the *El Niño* event begins.

Data and Methodology

The following data set is employed for the analysis purposes.

Data	Time frame	Source
Rainfall amount (mm)	1990-2015, monthly data	MPOB - Data originated from Malaysian Meteorology Department (MET) and compiled by MPOB
Sea surface temperature (°C)	1990-2015, monthly data	National Oceanic and Atmospheric Administration (NOAA), USA
Soyabean oil prices (USD/ million tonnes)	2006-2015, monthly data	Bloomberg
CPO prices (USD/million tonnes)	2006-2015, monthly data	Bloomberg
CPO production (million tonnes)	2006-2015, monthly data	MPOB
Palm oil export (million tonnes)	2006-2015, monthly data	MPOB

A simple correlation study and a Granger causality test are employed to analyse how *El Niño* and *La Niña* influence Malaysian weather pattern. This paper will also utilise the ordinary linear regression to examine the relationship between weather and the crude palm oil price movement.

How *El Niño* and *La Niña* influence Malaysian weather

The occurrence of *El Niño* and *La Niña* events tend to disrupt the global weather pattern. However, their impact varies from place to place, depending on the intensity of the ENSO event. An ENSO event, in general, affects the variability of precipitation or amount of rainfall in Malaysia. Analysis of the monthly rainfall data recorded by the Malaysian Palm Oil Board's (MPOB) stations all over Malaysia from 1990 to 2015, and data on monthly sea surface temperature[1] (SST) anomalies from the National Oceanic and Atmospheric Administration (NOAA), U.S.A. showed that despite recording a low correlation value of -17%, the Granger causality test shows that SST significantly influenced rainfall pattern in Malaysia (*Table 1*). A Granger-causality analysis was carried out in order to assess whether SST has any potential predictability power on the amount of precipitation in Malaysia. The conclusion that can be drawn is that both SST and rainfall have significant bidirectional causality. In this case, SST did influence the amount of rainfall in Malaysia, and *vice versa*.

TABLE 1. PAIRWISE GRANGER CAUSALITY TESTS USING DATA SET COLLECTED FROM 1990 TO 2015

Null hypothesis:	Obs.	F-statistic	Prob.
SST does not cause Rainfall	310	2.84040	0.0599*
Rainfall does not cause SST		5.06784	0.006**

Note: '*' and '**' indicate statistical significance at the 5% and 10% probability levels, respectively.

Analysis of the same data set found that the effect of the ENSO events was more prominent in Sabah and Sarawak than in Peninsular Malaysia. The correlation coefficient between SST anomalies and the amounts of rainfall in Sabah, Sarawak, and Peninsular in the year of 1990 until 2015 was -37, -20 and -7%, respectively. However, the impact of the ENSO events on the level of precipitation in Malaysia was clearer during a severe ENSO episode such as in 1997-1998. The correlation between SST and the amounts of rainfall in Sabah, Sarawak and Peninsular in January 1997 to December 1998 was then -56%, -42% and -24%, respectively, much higher than the earlier correlation values.

During the strongest *El Niño* event in 1997-1998, Malaysia experienced a substantial decrease in rainfall, dropping more than 50% from the level of 200 mm in April 1997 to a low value of 58 mm in February 1998. Subsequent to the *El Niño* event, Malaysia had experienced a *La Niña* phenomenon when the rainfall in Malaysia increased to 365 mm in December 1999. This was influenced by the decline in SST from a positive anomaly of 0.6°C in early 1998 to a negative anomaly of -1.67°C in early 1999. In the presence of a strong *El Niño* event (Oct 1997 to March 1998), the rainfall in East Malaysia decreased by about 37% compared with Peninsular which recorded a drop in rainfall by 7% during the severe period of *El Niño*.

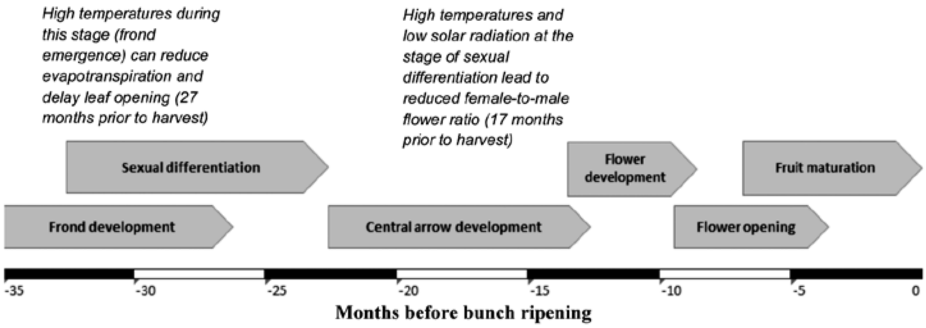
How do *El Niño* and *La Niña* events affect the production of palm oil?

As a tropical plant, the oil palm requires an evenly distributed annual rainfall of 1500 to 2000 mm or more, without a defined dry season. Best oil palm yields are obtained in those areas where there is a maximum average temperature of 29ºC-33ºC and a minimum average temperature of 22ºC-24ºC. The crop requires constant sunlight of at least five hours per day for better oil palm yield (Tarmizi and Kushairi, 2014). Therefore, a close monitoring on the weather is needed to optimise the output from the oil palm.

The growth and yield of oil palm depend largely on the climatic characteristics of the environment. For oil palm, the occurrence of adverse weather conditions, such as *El Niño* or *La Niña* events do not directly or immediately affect the palms. Instead, it affects processes at an earlier growth stage, such as frond production, sex ratio, the extent of floral abortion, the degree of survival of flowers after anthesis and bunch weight (Verheye, 2010). The variation in several development stages of palm oil contributes to the cycle of fresh fruit bunch production. The variation of sex ratio, for example, is one of the important elements in determining the oil palm yield. An increase in males relative to other inflorescences causes the decline in the fruit bunch numbers (Henson, 2005). These will consequently influence, and in turn, will determine oil palm yield. The yield will be affected when palms are exposed to stress conditions, *e.g.* low soil moisture due to prolonged dry and hot weather conditions. Oil palm need at least 100 mm of rainfall every month. Rainfall below this amount will disrupt the development of the fruit bunches and affect production in the next 10 to 24 months following the event (Shanmuganathan and Narayanan, 2012).

Figure 1 summarises the major phenological growth stages of oil palm that are responsive to the changes in climatic conditions. As the flowering process happens at the axil of each frond, the rate of frond production and sex determination will determine the number of the fruit bunches.

[1] SST is a key climate and weather measurement obtained by satellite microwave radiometers, infrared (IR) radiometers, in situ moored and drifting buoys, and ships of opportunity. Different instruments measure the temperature at different depths. (http://www.remss.com/measurements/sea-surface-temperature)



Source: Shanmuganathan and Narayanan (2012).

Figure 1. Oil palm life cycle and approximate timing of processes related to fruit bunch development.

Therefore, any interruption during frond development (leaf opening) will consequently affect the FFB yield in the subsequent 24-36 months. The sex determination occurs twenty-four months before fruits ripening. If palms are subjected to water stress at this point of time, a reduction in sex ratio will occur (higher male inflorescences). This will affect the development of fruit bunches (Harun *et al*., 2010).

The occurrence of *La Niña* event following an *El Niño* episode will normally cause FFB yield to increase sharply. This event has brought a good rainfall to nourish the palm plantations after severe dry weather. However, the unusual amount of rainfall may cause a continuous water-logging which then will negatively affect the growth of oil palm. Prolonged waterlogging (more than 3 months) in the estates could hinder the respiration of oil palm roots and consequently kills the palms. With prolonged waterlogging, not only the roots are unable to respire but the uptake of nutrients is also limited, which in turn affects the growth and yield of oil palm (Corley & Tinker, 2003). Besides the impact on the respiration process, heavy rainfall also causes lower pollination which occurs six months before fruit maturity. Less pollination will reduce bunch fruit set and lead to the reduction in the mean fruit bunch weight (Harun *et al*., 2010). Additionally, an excessive amount of rainfall could also cause flooding which would disrupt FFB harvesting and FFB collection activities. The transport of FFB from the estate to oil palm mill could be disrupted during floods, causing FFB to become overripe and rotten, and consequently reducing both FFB yield and CPO production.

Economic impact of *El Niño* and *La Niña* on palm oil industry

The anticipation of the occurrence of a strong ENSO event will partly influence CPO prices since such event is an important factor in determining FFB yield and CPO production. Thus, any significant changes in the amount of rainfall will be reflected in the supply pattern of palm oil, and will consequently influence CPO price movements.

The strong occurrence of *El Niño* event will influence the price movements. This can be seen during the 1997-1998 period when a strong *El Niño* event occurred, pushing CPO prices from an average of RM 1350 t^{-1} to almost RM 2400 t^{-1}, an increase of 78% within a year. Based on the results from a linear regression analysis, it is suggested that there is no significant relationship between rainfall and CPO prices, but it does affect CPO production. The regression analysis suggest that for every 1% decline in CPO production, which may be due to the unfavorable amount of rainfall received, will influence CPO prices to increase by 0.04% (*Table 2*).

$$CPOP_i = \alpha + \beta_1 SBO_i - \beta_2 POPROD_i + \beta_3 POEX_i + \beta_4 RAINFALL_i + \varepsilon_I$$

where:
CPOP = crude palm oil price in USD/million tonnes
SBO = soyabean oil price in USD/million tonnes
POPROD = palm oil production in million tonnes
POEX = palm oil export in million tonnes

As mentioned earlier, rainfall is the key element of the oil palm growth. CPO production is affected in both extreme cases of rainfall amount, *i.e*, low rainfall is classified by monthly rainfalls less than 200 mm per month and high rainfall is classified by monthly rainfalls more than 200 mm per month. It has been found that there was a significant reduction in FFB yield after five months lag period of high rainfall month. Similarly, low rainfall was followed by an improved in FFB yield after five months lag period. This implies that FFB yield was affected by the amount of rainfall received, to some extent through pollination or fruit set (Harun *et al*., 2016). Apart from production, *Table 2* also suggests that the movement in CPO prices was also influenced by the price of its close substitute product namely soyabean oil and the demand of the CPO itself which can be measured by the volume of palm oil export.

CONCLUSION

In conclusion, the occurrence of *El Niño* event is found to influence Malaysian weather through the amount of precipitation which in turn significantly influences the palm oil production pattern in Malaysia. However, the impact arising from adverse weather conditions on crop productivity was subject to the intensity of the *El Niño* event. A mild and weak *El Niño*, for instance, will not give much impact to the country. However, a moderate or strong *El-Niño* can cause rainfall to be lower than normal, particularly over East Malaysia, hence affecting the oil palm production pattern. The impact of *El Niño* event on CPO production was not immediate. Prolonged hot and dry weather affects the key physiological stages relating to inflorescence abortion and sex determination which has a lag period of 9-11 and 22-23 months before FFB is harvested, respectively. As a consequence, the effects of a strong *El Niño* can be seen only 9 to 24 months after the event. Meanwhile during *La Niña* event, CPO production is affected due to the disruptions in harvesting and FFB collection caused by floods. As the water level subsides, FFB harvesting and collection will resume. On top of that, heavy rainfall could also affect the fruit bunch development. Poor pollination of anthesis female flowers by the pollinating weevils during heavy rainfall contributes to lower fruit set and bunch weight (Harun *et al*., 2010). In the extreme case, if the palms are submerged for more than three months, there is a high chance of the palm, particularly young palms, to die. Therefore, it is important for planters to have a good water management system to reduce the impact of climate variability on the oil palm industry and reduce the shock arising from these events impact on CPO prices that could consequently affect Malaysia's GDP as palm oil is one of the major contributors to government revenue.

TABLE 2. LINEAR REGRESSION ANALYSIS OF CPO PRICES

Independent variable	B	SE	t-stat	Prob
Constant	- 2.0183	0.7065	- 2.8569	0.0051*
Ln Soyabean Oil Price	0.8322	0.0275	30.2208	0.0000*
Ln CPO Production	- 0.0461	0.0161	- 2.8562	0.0051*
Ln PO Export	0.2700	0.0600	4.5152	0.0000*
Ln Rainfall	0.0335	0.0217	1.5408	0.1261
Adjusted R^2	*0.9039*			
N	*120*			

Note: '*' statistical significance at 1%.

ACKNOWLEDGEMENT

The author would like to thank the Director-General of MPOB for permission to publish this article.

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