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THE EFFECT OF LA NINA ON FRUITS PRODUCTION OF THREE CITRUS VARIETIES IN HIGH LAND

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ABSTRACT
In tropical climates, citrus flowering is controlled primarily by the availability of water (wet-dry). Therefore, the phenomenon of La Nina in 2016 which led to changes in rainfall will definitely affect flowering and fruits production in 2017. The aim of this research was to study the effect of La Nina in 2016 on the production of three varieties of citrus in 2017. This activity was conducted from January 2016 to February 2017 in the experimental field of Kliran, Balitjestro, located on 950 meters above sea level. Plants used in this study were three varieties of mandarin (*Citrus reticulata*) namely Keprok Batu 55, Keprok Madura, and Keprok Terigas planted in dry land Inceptisol in January 2014. The results showed that wet months that occurred during the year 2016 (La Nina) inhibited flowering of Keprok Batu 55 and Keprok Madura varieties which causing the plants failed to produce fruits in 2017. On the other hand, Terigas variety could bloom several times a year and the number of fruit / tree was high. This phenomenon showed that Terigas is more resilient to La Nina than the other varieties observed.

KEY WORDS
Keprok Batu 55, Keprok Madura, Keprok Terigas, La Nina, fruits production.

Indonesia including tropical region, consists of thousands of islands that include lowland to highland (mountainous). Mandarin citrus is the most economically important fruit crop in the highland particularly the area around the volcano, among others in East Java (Malang District, Batu City), West Java (Garut District) and North Sumatra (Karo District, Brastagi and Simalungun). Soils in the highlands formed from volcanic material with unique climate characters suitable for the cultivation of mandarins citrus because it can produce better fruit quality and color of the fruit is more interesting than the lowlands.

Citrus trees after past the juvenile phase will bloom every year, and annual flowering of adult trees is affected by several exogenous and endogenous factors. Many researchers claim that cool temperature can induce citrus flowering, as in most tropical and subtropical trees. In satsuma mandarin, floral induction occurs in trees exposed to 15°C for more than 1.5 months (Inoue, 1990; Moss, 1976; Nishikawa et al., 2007; Wilkie et al., 2008). Under Florida conditions, greater accumulation of hours of temperatures 11 to 15 °C increased floral intensity by the combined effect on the number of sprouting buds with reproductive growth and the number of flowers per flowering bud. Some statistical analyses indicated that high winter temperatures reduced flowering in 'Valencia' and 'Hamlin' oranges (Valiente, J.I. and L.G. Albrigo, 2004). On the other hand, many researchers stating that citrus flowering in the tropical regions is controlled primarily by availability of water (Davies, FS and LG Albrigo., 1994 and Cassin et al., 1969; Koshita, Y. And T. Takahara, 2003). Drought is known to induce flowering in citrus (Inoue, 1989; Nakajima, 1993; and Southwick and Davenport, 1986).

The above phenomenon shows that La Nina that led to increased the intensity of rainfall has serious impacts on growth, flowering, production and crop quality (Tubiello, F.N. et al., 2002;; Deuter, P. 2008; DaMatta, F.M. et al., 2010; Iglesias, A., S. Quiroga, and J. Schlickenrieder, 2010, FAO, 2016). Lately, phenomenon of La Nina becoming more frequent and caused economic losses to the citrus farmer due to crop failure. However, the extent of influence La Nina on decline citrus fruit production in Indonesia has not been studied.

Therefore, the aim of this research was to study the effect of La Nina in 2016 on the production of three varieties of citrus in 2017.

MATERIALS AND METHODS OF RESEARCH

The experiment was carried out from January 2016 to February 2017 in the experimental field of Kliran, Balitjestro, located on 950 meters above sea level. Plants used in this study were three varieties of mandarin (*Citrus reticulata*) namely Keprok Terigas, Keprok Madura, and Keprok Batu 55 grafted onto *Japansche citroen* rootstocks. Citrus planted in dry land, Inceptisol in January 2014 and the first harvest was done in 2006. Tree spacing was 3 m x 3 m; the average of trees high and crown width were 2.49 m and 1.77 m for Keprok Terigas, 2.97 and 1.78 m for Keprok Madura, and 3,25 and 77 m for Keprok Batu 55. Trees were kept under similar cultural practices (fertilizers, weed control, irrigation, and pruning). Fertilizer was applied three times a year, namely 500 g NPK (15-15-15)/tree.

Amount of fruit per tree was observed in February 2017 on 80 plants every variety. Climate elements data include average temperature, maximum temperature, minimum temperature, monthly rainfall and number of rainy days in 2016 were recorded from Climatological Stations at the Experimental Field of Punten, Balitjestro, altitude around 950 m above sea level, about 3 km in the South of experimen place. The data of naturally soil moisture were collected from Terigas citrus orchard (soil depth 0-30 cm) at the Experimental Field of Tlekung, Balitjestro that have soil type and altitude similiar to research place.

RESULTS AND DISCUSSION

Climatic Conditions and Soil Moisture. Climate data in the nearest climatological station showed that average monthly air temperature in 2015 were 20.34 to 23.28^{o}C with the hotest temperature was 29.17^{o}C (November) and the collest temperature was 17.49 ^{o}C (August). The average monthly air temperature in 2016 were 21.25 to 23.37^{o}C with the hotest temperature was 28,86^{o}C (November) and the collest temperature was 19.41 ^{o}C (August). This phenomenon shows that La Nina caused the average monthly air temperature increases and the difference between the hottest temperature with the coldest temperatures is smaller. According to Albrigo, L.G. (2007), for citrus specifically, potential climate changes could effect growth and production through at least 3 weather changes: temperature effects on flower bud induction and fruit development, drought and water availability effects on growth and possible increases in hurricanes impacting tree condition and crop load. If average temperatures were to increase 2^{o} C, then the average level of flower bud induction from low temperature induction would decrease and fewer years with adequate cool temperature accumulation for flower bud induction would occur.

The anual rainfall in 2015 recorded 1,387 mm and for one year experienced six dry months (<60 mm) from June until September and November. This conditions different from year 2016, the annual rainfall were 2.365 mm with dry month twice only and disconnected, namely April and July, while the rest were humid and wet months (Figure 1). This phenomenon is consistent with the statement by Hirons, L. and N. Klingaman (2016), that the climate in Indonesia that is usually in June-August was dry, then changed to wet.

On dry land, soil moisture conditions are very dependent on the volume and distribution of annual rainfall that ultimately affect the plant phenology (Koshita, Y. and T. Takahara, 2003; Myer at al., 1975; and Morgan, K.T., 2009). Measurement of soil moisture at depths 0 to 30 cm (rhizosphere) at citrus orchard without irrigation by gravimetric method showed that rhizosphere of citrus trees was always moist with soil water contents more than 55 percent of field capacity, except on September (Figure 2) .

The flowering process is the initial phase of citrus trees to form fruits, and once past the juvenile phase, trees bloom every year. Annual flowering of adult trees is affected by several exogenous and endogenous factors. Many researchers suggested that Water stress is the main factor that induces flowering in the tropics. According to (Cassin et al., 1969; Borroto et al., 1977; Lovatt et al., 1984), citrus in a tropical climate required at least 45 to 60 days of water stress to induce an economic level of flowering, while more than 70 continuous days of water stress may be detrimental to tree health and productivity. This statement is in line with observation result on varieties of Keprok Madura and Keprok Batu 55 but different from Keprok Terigas. Although dry month period very short (one month), Keprok Terigas variety can bloom many time, at least three periode a year with peak levels in December.

Table 1 – Data average temperature, maximum temperature, and minimum temperature in Year 2015 and 2016 in Climatological Stations at the Experimental Field of Punten, Balitjestro

Month	Average temperature (^{0}c)		Maximum temperature (^{0}c)		Minimum temperature (^{0}c)	
	Year 2015	Year 2016	Year 2015	Year 2016	Year 2015	Year 2016
Jan.	22.55	22.98	26.11	28.30	20.66	21.72
Feb.	22.70	22.36	26.82	26.67	21.51	21.03
Mar.	22.78	22.94	26.90	27.24	21.17	21.43
Apr.	22.84	23.37	26.92	27.96	21.43	21.67
May	22.12	23.20	26.42	28.36	20.19	21.48
Jun.	21.00	22.38	25.47	26.95	18.97	20.54
Jul.	20.34	21.98	25.64	27.23	17.66	20.12
Aug.	20.28	21.25	25.20	25.81	17.49	19.41
Sep.	21.58	22.74	27.45	20.73	18.73	28.33
Oct.	23.28	23.11	29.03	28.45	20.59	21.90
Nov.	22.69	22.85	29.17	28.86	21.83	21.89
Dec.	22.20	22.85	26.96	27.12	21.69	21.97

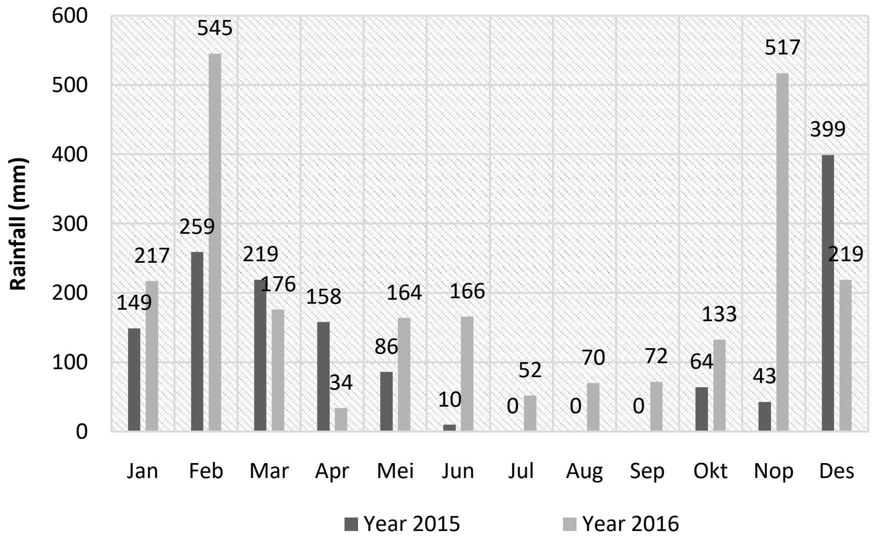

Figure 1 – Monthly Rainfall on Climatological Stations at the Experimental Field of Punten, Balitjestro in Year 2015 and 2016

Fruits Production. In citrus, cool temperature can induce flowering, as in most tropical and subtropical trees (Inoue, 1990b; Lenz, 1969; Moss, 1976; Nishikawa et al., 2007; Wilkie et al., 2008). In satsuma mandarin, floral induction occurs in trees exposed to 15°C for more than 1.5 months (Inoue, 1990b; Nishikawa et al., 2007).

Until the end of February 2017, all of the sample trees of Keprok Terigas support the fruit with total amount of fruit 17,727 or increased 40 percent from the previous year's production (2016). The fruits were produced from three times flowering namely in August / September, October and flowering peak in December 2016 (Picture 3). In January 2017, Keprok Terigas trees bloom again in fairly large numbers. Therefore, the tree has three levels of fruit size / age so that it will harvest at different times. This is different from Keprok Madura and Keprok Batu 55 which most of the trees do not bloom. This experiment's results show that amount of trees that support fruit in February 2017 only 12 percent for Keprok

Madura and 26 percent for Keprok Batu 55 (Tabel 2). The production of both varieties decreased dramatically compared to fruits harvest in the year 2016. The amount of fruit produced by Keprok Madura only 18 percent from the previous year's production, and only 40 percent for Keprok Batu 55. This fact also illustrates that genetically Keprok Terigas variety resistant to prolonged rainfall or wet soils, otherwise varieties of Keprok Madura and Keprok Batu 55 require a dry period sufficient to flowering and fruiting at an economical level.

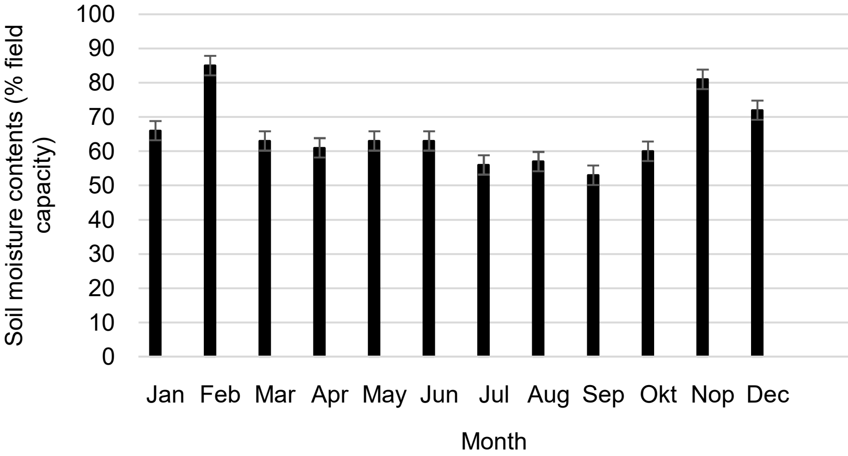

Figure 2 – Soil Water Contents at Citrus Rhizosphere Zone on Citrus Orchard in The Experimental Field of Tlekung, Balitjestro on 2016

Table 2 – Fruits Production of Keprok Terigas, Keprok Madura, and Keprok Batu 55 at Experimental Field of Kliran, Balitjestro in 2017 and 2016

Variety	The percentage of sample trees that support fruit in February 2017	The total amount of fruit in February 2017	The amount of fruit harvested in 2016
Keprok Terigas	100	17,727	12,640
Keprok Madura	12	194	1,080
Keprok Batu 55	26	936	2,340

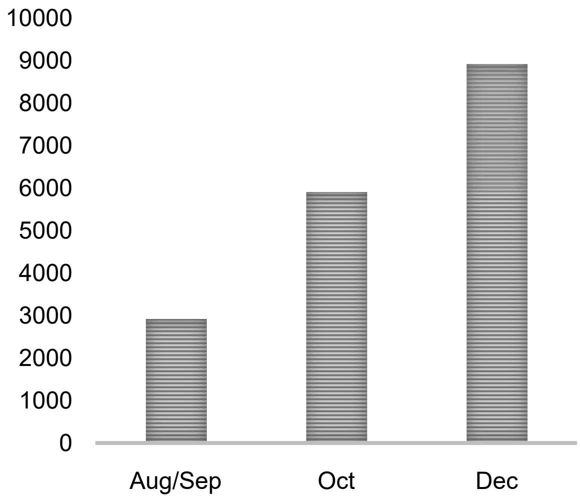

Figure 3 – Amount of Keprok Terigas Fruits that Production From Flowering in August/September, November and December 2916

Several authors have proposed that low temperatures may have a dual effect releasing bud dormancy and inducing flowering (Southwick and Davenport, 1986; García-Luis et al., 1989, 1992; Tisserat et al., 1990). Moreover, temperatures under 20ºC have been demonstrated to contribute to flower bud induction in a time dependent manner (Southwik and Davenport, 1986; García-Luis et al., 1992). However, this result showed that low temperature (19.41°C) during August period without adequate water stress was not followed by optimal flowering. this is due to the absence of sharp seasonal changes in temperature. This phenomenon confirm that under tropical conditions like Indonesia, generally citrus flowering more strongly affected by water stress according to the statement of some researchers (Inoue, 1989b; Nakajima, 1993; Southwick and Davenport, 1986).

CONCLUSION AND SUGGESTIONS

From the results of research in the given conclusion that mandarin citrus varieties have different responses to La Nina. Prolonged rainfall or wet soils throughout the year as the impact of La Nina did not affect on fruits production of Keprok Terigas. Impact La Nina on Keprok Madura and Keprok Batu 55 were decreases the fruit production around 60-80 percent because plants had no enough water stress period for flower induction.

Keprok Terigas including varieties that are resistant to excess water so that ca can be selected for the highlands that have high rainfall and beneficial to minimize harvest failure due to climate change.

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