Extention of Oil Palm in altitude under Global Change in North Sumatra : ecophysiological responses and yield

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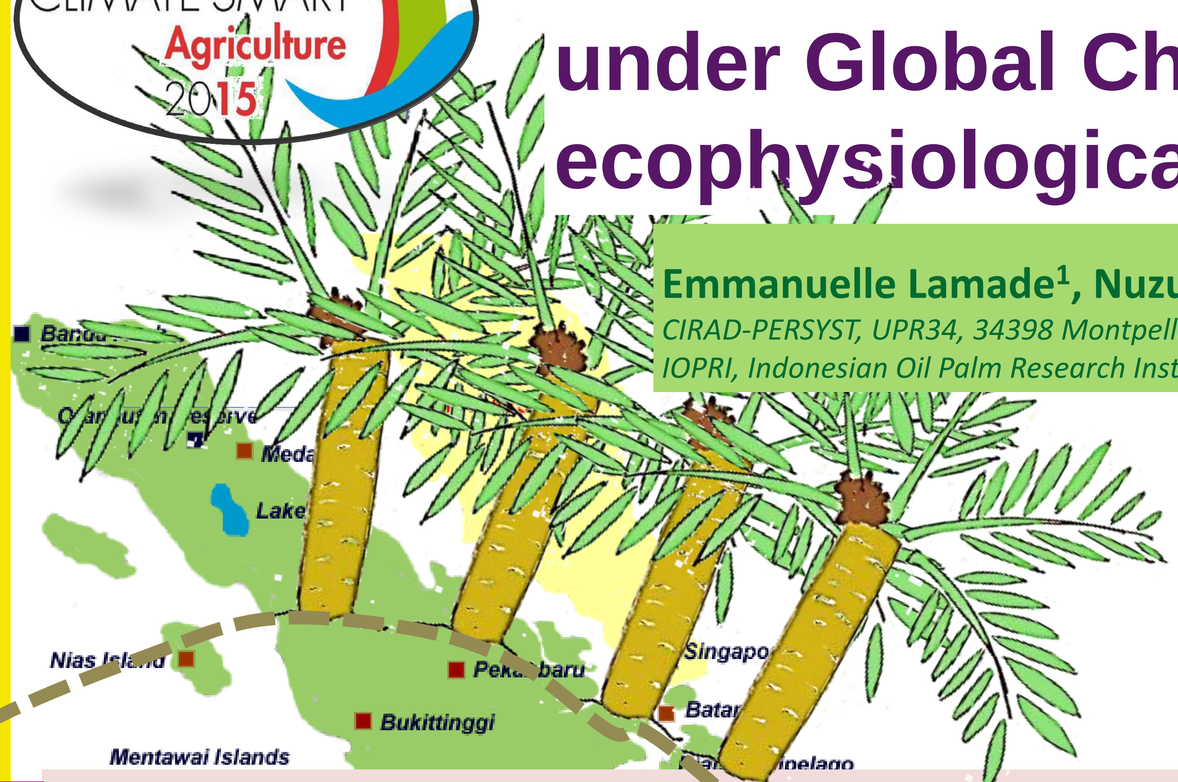

Introduction

Global change effect in North Sumatra has provoked an increase of the minimum temperature in some highlands traditionnaly devoted to tea plantations. This temperature increase has potentialy benefited to oil extention replacing tea .Today, total areas of highland oil palm is reaching 4700 ha distributed from 500 m 1000 m asl. Because oil palm planters have placed a bet on new extention, agro-ecological conditions are still far to reach maximum productivity.There is a need for physiological studies to identify and quantify main constraint factor for yield metabolism for selecting best adapted materials and elaborated new cropping practices.

Materials and Methods (Table 1)

Climatic data series have been recorded at 3 elevations in North Sumatra. (1) Medan : 27 m asl (2) Marihat : 369 m asl (3) Bah Butong : 850 m asl from 1970 to 2005. Leaf gas exchanges (photosynthesis and transpiration) were measured during 2007 at 3 elevations. (1) Marihat –Andarasi 369 m (2) Balimbingan from 550 to 580 m (3) Bah Birung Ulu from 650 m to 820m on *Deli x Yangambi* material, planted in 1995. A portable photosynthesis system (LICOR 6400, Licor Inc., USA, photo 1) was used on leaflets at B point on leaf rank 17. A tower of 15 m (photo 2) high was used to reach canopy. Vegetative parameters as trunk height and diameter, petioles and rachis lenght and width were done on 20 trees at Balimbingam , Bah Birung Ulu and Gunung Bayu. Bunch production was followed during 2000-2008 for almost 26 blocks distributed along 650 m to 825 m asl.

Leaf gas exchanges study with the Licor 6400 on oil palm leaf at Bah Birung Ulu Estate, North Sumatra.

Experimental design for leaf gas exchange study at BBU 5 and 25 : tower at 15 m.

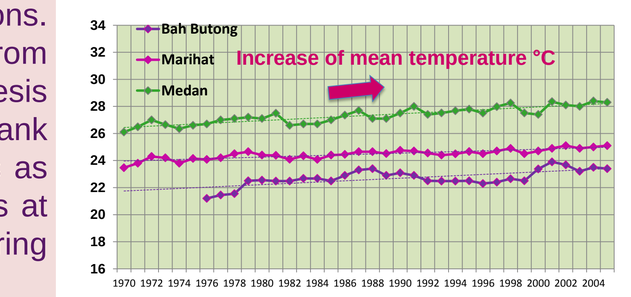

Fig. 1. Average annual temperature for 3 locations (1),(2),(3). From Darlan et al. 2009..

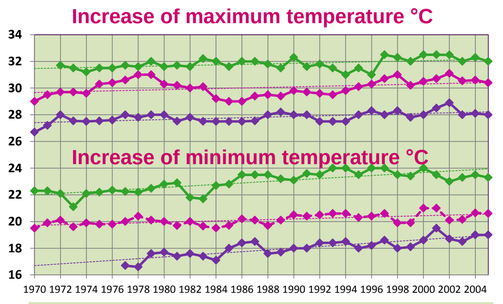

Fig. 2. Minimum and maximum annual temperature for 3 locations (1),(2),(3), from Darlan et al. 2009.

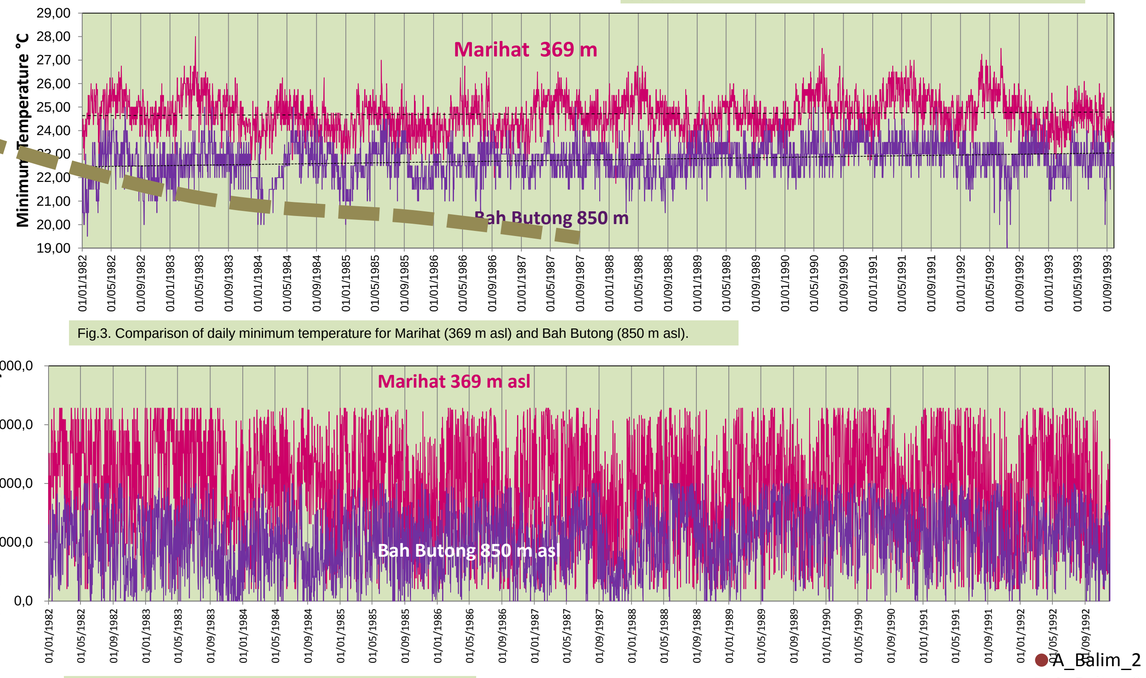

Fig.3. Comparison of daily minimum temperature for Marihat (369 m asl) and Bah Butong (850 m asl).

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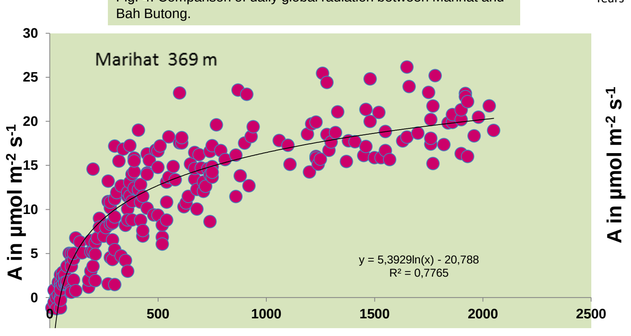
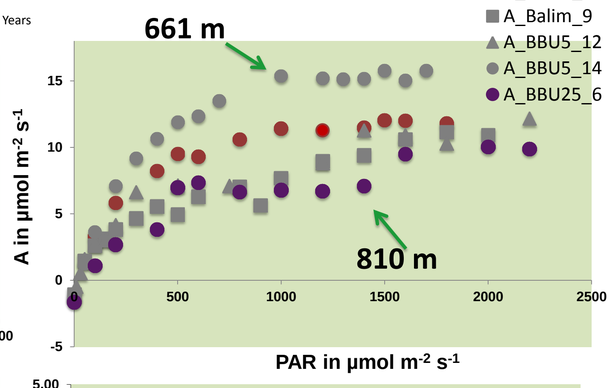
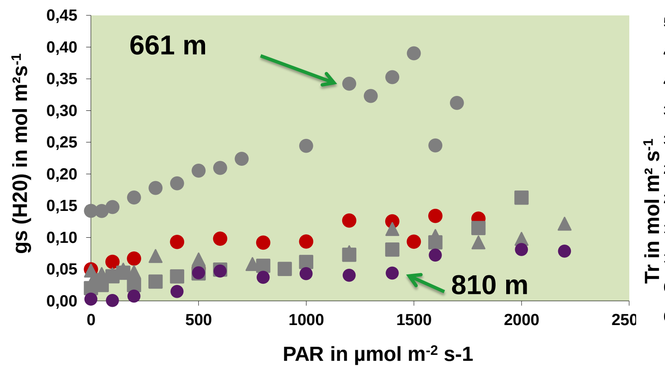
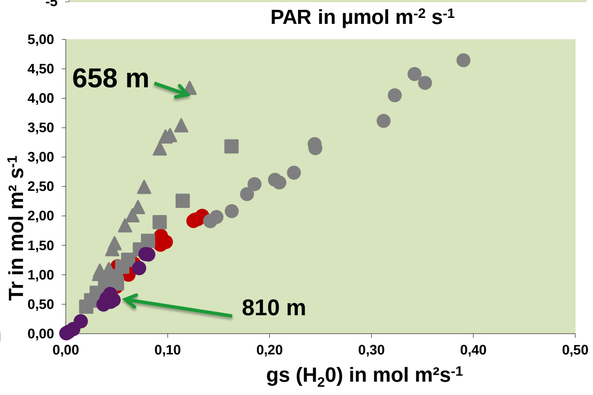
Fig. 4. Comparison of daily global radiation between Marihat and Bah Butong.









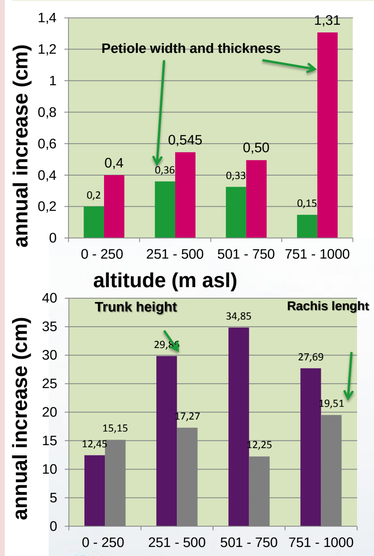


Fig.5 & 6. Photosynthesis Response to PAR for *Deli xYangambi* trees at Andarasi (Marihat) 369 m. Same for different elevations on trees studied in Balimbingan and Bah Birung Ulu.

Fig. 7 & 8. Response of Gs to PAR for trees at different elevations in Balimbingan and Bah Birung Ulu. Relation between Tr (Transpiration) and Gs (stomatal conductance) for same trees.

Fig. 9 & 10. Vegetative studies on oil palm tress along altitude gradient.

Block	Balim	BBU 5	BBU 25
Altitude	550-580 m	650-680 m	815-820 m
Palm studied for leaf gas exchange	N° 2 = 552 m N°9 = 560 m	N°1= 652 m N°12 = 658 m N° 14 = 661 m N° 19 = 656 m	N° 6 = 810 m N° 11 = 820 m
table 1 : trees	studied for	leaf gas	exchanges

Fig. 11. Performances in FFB for oil palm trees at different ages and different altitudes in North Sumatra (from Darlan et al. 2009)

Results

- Climate change (Fig.1,2,3,4)

A temperature elevation has been noticed during 1970-2005 at 3 locations (1) Medan-27 m-, (2) Marihat-369 m-, (3) Bah Butong-850 m. Minimum temperature increased around 1.8 °C ((1) : +1.5 °C; (2) : +1.3 °C; (3) : from 1.3 to 1.8°C). Mean temperature showed an increase of 1.4 °C ((1) : +1.1 °C; (2) : 0.8-1.1°C; (3) : 1.1-1.4 °C). Higher increase for maximal temperature is seen at location (1) with +1.5 °C. The low global radiation- under 14 Mj m^{-2} day^{-1} is, with the low temperature, at 850 m asl main important parameter responsible for low carbon metabolism.

- Gas exchanges (Fig.5,6,7,8)

An effect of the altitude is observed for the photosynthesis asymptote value at PAR sat (>1100 µmolm^{-2} s^{-1}) for oil palm tree leaflets. For Marihat trees : Amax = 19 µmol m^{-2} s^{-1}, for Balim 11 tree, BB5 13 and BB25 Amax < 9 µmol m^{-2} s^{-1} . A loss of 40 % is observed for an elevation of 400 m. Transpiration rate in relation with Gs revealed a loss of 50 % of efficiency between 600 and 800 m asl when facing high relative humidity.

- Vegetative growth (Fig. 9,10)

Main effect of the altitude can be seen on trunk height with a growth rate >34 cm/yr until 750 m then a decrease (28 cm/yr) is observed until 1000 m asl. Other effect of altitude seems obvious on petiole thickness (3 time more when changing from 250 m to 1000 m). As for trunk height, accumulation of sugars may be responsible for these observations.

- Yield (Fig.11)

If altitude effect is low at young stage with only a decrease equal to 25 % at 800 m asl, after 7 years, a production decrease of 40 % is observed. At 13 years old, the yield lost reach es 60 % (10 t FFB) compared to standard (25 t FFB).

Conclusion

Global Change in North Sumatra is not only responsible for an increase of CO_2 but also for an increase of the minimum temperature in altitude which benefit to oil palm extention in highlands where oil palm supposed to be more profitable is replacing tea plantations. This study pointed out the effect of low temperature, low radiation and high relative humidity on gas exchange in relation with growth and yield metabolism. It is observed a decrease of 60 % of the production at elevation > 850 m asl related to a decrease of 40 % of the photosynthesis. In order to improve sustainable yield, already profitable for oil palm, in Sumatra highlands, new adapted planting material, tolerant to low temperature has to be produced and planted in such areas. Innovated cropping practices (eco-friendly : adapted fertilizer input, new planting density, special prunning, biological control for Marasmius and so one…) must completed this new land extention.

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