RELATIONSHIP BETWEEN CHLOROPHYLL CONTENT AND CHLOROPHYLL FLUORESCENCE PARAMETERS ON FRUIT YIELD OF *Jatropha curcas* L.

Buppa Kongsamai[1*], Pojana Simantara[2] and Nipaporn Bua-In[1]

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Abstract

Relationship between chlorophyll content and chlorophyll fluorescence parameters on fruit yield of *Jatropha curcas* L., accessions KUBP20-4, KUBP78-9 and KUBP16, was studied. The experiment was conducted at Kamphaeng Saen, Nakorn Pathom during June-October 2010, laid out in Randomized Complete Block design with 6 replications. Chlorophyll fluorescence parameters and chlorophyll content measured with SPAD meter were assessed and elucidated. The result showed that fruit yield was highest for KUBP78-9 with statistically significant difference from KUBP16 variety and KUBP20-4. Chlorophyll fluorescence parameters, ΔF/Fm' and qP, were found significantly different among accessions. ΔF/Fm' and qP value of KUBP78-9 were highest, which were of 0.801 and 0.800, respectively. The ΔF/Fm' and qP were lowest in KUBP20-4. Similar response was also observed for the leaf chlorophyll content. This result indicated that there was a relationship between chlorophyll fluorescence parameter, chlorophyll content and fruit yield of *J. curcas*, which could be developed as a potential method to assess growth and fruit yield.

Keywords: ***Jatropha curcas* L., chlorophyll fluorescence, SPAD, fruit yield**

Introduction

Jatropha (*Jatropha curcas* L.) is a potential multipurpose plant with many attributes especially for oil that can be used instead of kerosene and diesel (Openshaw, 2000). Seed yield of *J. curcas* is one of the desirable traits for intensive cultivation. Its yield planted in Thailand was ranged from 2.0 to 2.5 t ha^{-1}. Its productivity depends on the amount of photosynthetically active radiation (PAR) absorbed and on the efficiency of the transformation of absorbed PAR into dry matter. Photosynthesis is classified as a fundamental biological process. Photons are absorbed by chlorophyll molecules and then the excitation energy is transferred to reaction center of the photosystems. The energy is

[1] *Department of Agronomy, Faculty of Agriculture at KamphaengSaen, Kasetsart University, Kamphaeng Saen, Nakorn Pathom, 73140, Thailand. E-mail: agrbuk@ku.ac.th*

[2] *Department of Farm Machanics, Faculty of Agriculture at KamphaengSaen, Kasetsart University, Kamphaeng Saen, Nakorn Pathom, 73140, Thailand.*

[*] *Corresponding author*

primary used in photochemical reactions and then initiating energy conversion in photochemical and biological pathways. Other competitive pathways represent the thermal dissipation and the chlorophyll fluorescence. Therefore, chlorophyll fluorescence measurement could use to estimate performance of electron transfer in photosynthesis system II (PSII) in leave that indicating photosynthesis performance in plant (Genty *et al*., 1989; Govindjee, 1995). The relationship between productivity and fluorescence was reported for some agricultural crops; forage crops (Boughalleb *et al*., 2009), rice (Cha-um *et al*., 2010), asparagus (Faville *et al*., 1999), wheat (Šlapakauskas and Ruzgas, 2005) and tomato (Zhu *et al*., 2012). In *J. curcas,* Silva *et al*. (2010) reported that some chlorophyll fluorescence parameters; quantum yield of primary photochemistry (ΔF'/Fm') and non-photochemical quenching (NPQ) could be used to reveal the membrane damage of *J. curcas* subjected to drought and heat stress. However, the relationship between yield, and fluorescence parameters as well as chlorophyll content in *J. curcas* has not been reported. Our aim was to observed for these relationships in three different accessions of *J. curcas* in the first year of growth and flowering.

Materials and Methods

Two month-old cutting seedlings of three accessions of *J. curcas*, KUBP20-4, KUBP78-9 and KUBP16, were transplanted in June 2010 at a spacing of 2 m in a three-row plot with three plants per row. Randomized Complete Block designwas laid out with 6 replications in an experimental plot of *J. curcas* located on the Kamphaeng Saen farm, Nakorn Pathom province. KUBP20-4 is a moderate yielding variety; its canopy is tall and leafy. KUBP78-9 is a high yielding variety with a compact canopy. KUBP16 is a moderately low yielding variety; its canopy is moderately tall. Three months after transplanting, mostplants started flowering. Canopy height was measured after two months of transplanting and percentage change relative to canopy height of the previous month was calculated. Yield was harvested from 3 plants in each replication and seed yield was calculated on a plant basis. Other yield component, harvested fruits per plant, and seed-oil content were also recorded. Chlorophyll fluorescence and chlorophyll content were measured at 7th leaf from the apex of each plant (Simantara *et al*., 2013). Chlorophyll fluorescence was measured using chlorophyll fluorometer (PAM 2100, walz GmBH, Germany) with 10 min dark adapted using leaf clip and Quantum yield (ΔF/Fm'), photochemical quenching (qP) andnon-photochemical quenching (qN) of fluorescent were accessed. Chlorophyll content was also measured using SPAD meter (SPAD-105, Minolta, Japan).

Results and Discussion

Canopy Height

Canopy height at the 2th month of transplanting was 41.7, 61.2 and 51.6 cm for KUBP16, KUBP20-4 and KUBP78-9, respectively. Percentage of canopy height change relative to canopy height of the previous month was observed from the 2th to 8th month after transplanting. It showed that relative canopy height was significantly different among accessions only at the first four months after transplanting. KUBP16 and KUBP78-9 had higher percentage of canopy height changes compare to KUBP20-4. The relative canopy height of each variety was non-significantly increased after the fourth month of transplanting (Figure 1).

Seed Yield and Yield Components

Seed yield per plant and fruit number per plant were significantly different among accessions. KUBP78-9 gave the highest seed yield and fruit number per plant of 555.1 g and 273.8 fruit, respectively, followed by KUBP20-4 and KUBP16 (Figure 2). Seed-oil content was highest for KUBP78-9 (49.7% seed dry weight) and lowest for KUBP16 (46.6% seed dry weight) (data not shown).

Chlorophyll Fluorescence and Chlorophyll Content

Chlorophyll fluorescence analysis allows non-invasive measurement of key aspects of photosynthetic light capture and electron transport (Campbell *et al*., 1998). Quantum yield (ΔF/Fm'), qP and qN for each accessions averaged over replications are shown in Figure 3. The ΔF/Fm' gives the proportion of absorbed light that is actually used in PSII photochemistry and used to estimate efficiency of PSII electron transport in the light. The qP is used to determine the level of photoprotective quenching of fluorescence (Murchie and Lawson, 2013). Accessions had influence on some parameters of chlorophyll fluorescence, especially on quantum yield (ΔF/Fm') and qP of *J. curcas* leaves but there was no effect on qN. The qN indicates that the three accessions of *J. curcas* had the same capacity for photoprotective thermal energy dissipation. (Ribeiro *et al*., 2004) KUBP78-9 gave the highest value of ΔF/Fm' and qP of 0.801 and 0.800, respectively. KUBP20-4 gave the lowest value of ΔF/Fm' (0.748) and qP (0.748). KUBP16 had the value of ΔF/Fm' and qP of 0.764 and 0.764, respectively. The photochemical activity evaluated by the quantum yield of primary photochemistry (ΔF/Fm') and photochemical quenching (qP) of KUBP78-9 was higher than those of KUBP16 and KUBP20 about

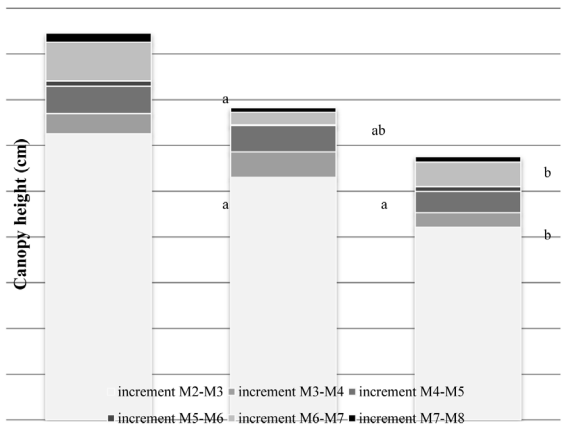

Figure 1. Canopy height change from the 2th to 8th month (M_2-M_8) of three accessions of *J. curcas;* KUBP20-4, KUBP78-9 and KUBP16. The same letters are not significantly different according to LSD test after ANOVA ($p < 0.01$)

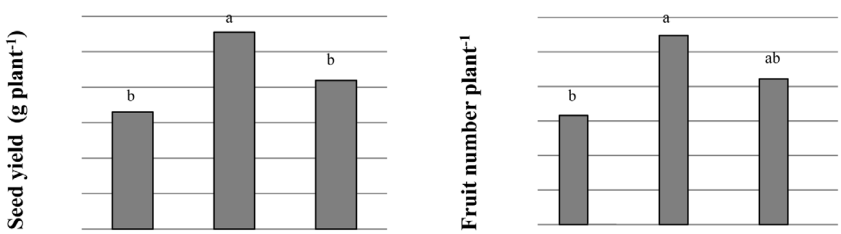

Figure 2. Seed yield and fruit number per plant collected from 3 accessions of *J. curcas;* KUBP20-4, KUBP78-9 and KUBP16. Data were based on five times of harvesting of the first year (October 2010-Janaury 2011). The same letters are not significantly different according to LSD test after ANOVA ($p < 0.01$)

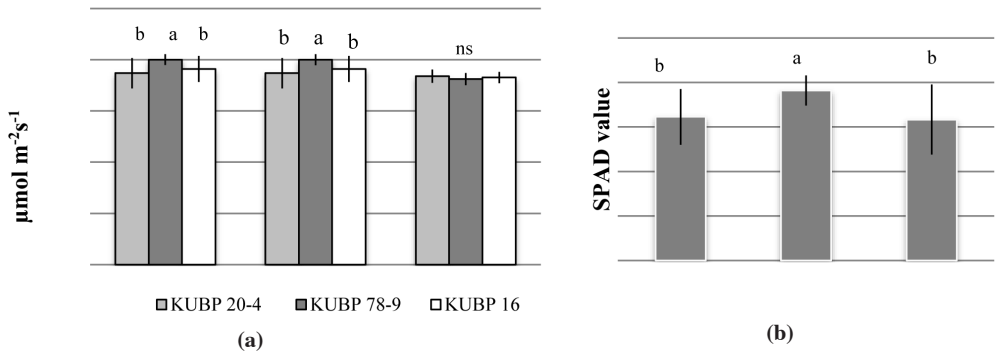

Figure 3. a) Chlorophyll fluorescence parameter, quantum yield (ΔF/Fm'), photochemical quenching (qP) andnon-photochemical quenching (qN), and b) chlorophyll content measured in SPAD unit were collected from the 3 accessions of *J. curcas*, KUBP20-4, KUBP78-9 and KUBP16. Data were recorded at 7th leaf from the top at 3rd month after transferring. Bar is mean value (n = 30) and standard deviation. The same letters are not significantly different according to LSD test after ANOVA (p < 0.01)

8% and 4.8%, respectively (Figure 3). Silva *et al*. (2010) was also reported that *J. curcas* cv. 'T1' grown in the appropriate cultivation had a quantum yield of 0.7-0.8. This value will be lower when the plants are grown in the stress condition. Leaf chlorophyll content is one of important factors determining photosynthetic capacity as it contains the reaction centers (Mao *et al*., 2007). SPAD unit is generally used to estimate leaf chlorophyll content in several crops (Uddling *et al*., 2007). KUBP78-9, a high yielding and high operating efficiency of the PSII photochemistry had the highest chlorophyll content relative to the other accessions. This indicates that there is a positive correlation between leaf photosynthesis and seed yield of *J. curcas*. Similar results had been reported by Hubbart (2007) and Zhu *et al*. (2012) in rice and tomato, respectively. In contrast, no correlation between these two factors was found in barley and rapeseed (Chongo and McVetty, 2001).

Conclusions

In general, there was varietal effects on photosynthetic parameter, chlorophyll content, canopy height and seed yield of *J. curcas*. KUBP78-9 had greater seed yield, ΔF/Fm', qP and chlorophyll content than other accessions. In addition, there was a positive correlation between seed yield and ΔF/Fm', seed yield and qP. This indicated that a variety with an improvement for higher efficiency of PSII photochemistry and an improvement of photosynthesis through crop management would be possible for improvementof fruit yield potential. The ΔF/Fm' andqP could be potentially used as an indicator for prediction of yield potential of this crop.

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