

# EFFECTS OF HIGH CARBON DIOXIDE LEVEL ON THE EMERGENCE OF OIL PALM POLLINATING WEEVIL, *Elaeidobius kamerunicus*

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## ABSTRACT

*Elaeidobius kamerunicus* is the main pollinating insect of oil palm in Malaysia. The increase of ambient carbon dioxide (CO<sub>2</sub>) may promote greater crop growth and yield of oil palm. However, *E. kamerunicus*' adaptability and survival under high CO<sub>2</sub> level are still unknown. An oil palm weevil emergence study was conducted in plant growth chambers with two CO<sub>2</sub> levels, 400 ppm and 800 ppm. The plant growth chambers were set at 27°C and 70% relative humidity for the entire study period. Spikelets were taken from apical, middle and basal regions of anthesis male inflorescences from 6-year old DxP palms under normal field conditions. The sampled spikelets were placed in clear plastic tubes with both open ends covered with muslin cloth. The emergence of adults was observed at two-day interval until 10 days after incubation. The total number of weevils which emerged from the spikelets at 400 ppm and 800 ppm CO<sub>2</sub> levels were 240 and 233 individuals, respectively. Doubling the ambient CO<sub>2</sub> level to 800 ppm had no effect on *E. kamerunicus* emergence in controlled condition. Further study on oil palm weevil adaptability and survival under high CO<sub>2</sub> level is needed to provide information on the effects of future climate change scenario and oil palm yield.

**Keywords:** *Elaeidobius kamerunicus*, oil palm pollinating insect, high CO<sub>2</sub>

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## INTRODUCTION

Over the next century, the atmospheric concentration of carbon dioxide (CO<sub>2</sub>) is anticipated to double (Watson *et al.*, 1996). Since 1970 to 2004, its annual emission increased by about 80% and the projection to continue to increase as much as 500-1000 ppm by the year 2100 (IPCC, 2007). Two profound effects on individual species and communities are expected: first, on the fertilising effect of CO<sub>2</sub> on plant growth and second, on changes in climate. The direct physiological effects of enriched CO<sub>2</sub> atmospheres for plant species are becoming increasingly well

documented (Curtis and Wang, 1998). Several of these effects may alter the quality and quantity of food available for insect herbivores. First, many C<sub>3</sub> plants (rice, soybean, peanut, potato, shrubs and trees) raised in CO<sub>2</sub>-enriched atmospheres have higher photosynthetic rates and grow faster, increasing the biomass of plant materials available to herbivorous insects.

The oil palm (*Elaeis guineensis*), being a C<sub>3</sub> plant, is expected to positively respond to increasing CO<sub>2</sub> levels thereby resulting to increase in growth biomass and fresh fruit bunch yield. Under high CO<sub>2</sub> condition, the fertilising effect can boost yield of C<sub>3</sub> crops by about 13% (Chandler and Le Page, 2007). Fruit bunch production of oil palm is influenced by the availability of nutrients, water, carbohydrate supply and pollination. Poor fruit set may result in bunch failure and losses in oil yield (Mohd Haniff and Mohd Roslan, 2002).

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Oil palm is entomophilous (Syed, 1979) such that its pollination efficiency is dependent on pollen supply and pollinator activity (Mohd Haniff and Mohd Roslan, 2002). Before the introduction of oil palm weevil (*Elaeidobius kamerunicus*), manual assisted pollination was implemented. This method was an expensive and labour-intensive operation (Basri, 1984). Pollens had to be harvested from anthesising male inflorescences and sprayed onto anthesising female flowers. *Elaeidobius kamerunicus* was brought into Malaysia in early 1982 to improve pollination efficiency (Syed *et al.*, 1982). This species is the most effective oil palm pollinator in Malaysia, even during wet season (Mohd Basri and Norman, 1997). The adult weevils feed and breed on male inflorescences at anthesis (Basri, 1984) and have close relationship with oil palm (Yue *et al.*, 2015). Weevil pollination increases fruit set and subsequently improves the oil palm yield (Ponnamma, 1999; Caudwell, 2011).

Commercial plantations with different palm ages need to maintain a suitable population level of *E. kamerunicus* (Bulgarellil *et al.*, 2002). This weevil carries more pollen and has good searching ability (Syed *et al.*, 1981). Population dynamic and activity of oil palm weevil are influenced by climatic conditions (Chee and Chiu, 1998). However, there is a lack of information on the weevil performance under high CO<sub>2</sub> condition. In this study, we focused on the effect of elevated CO<sub>2</sub> at double the ambient CO<sub>2</sub> level on the emergence of *E. kamerunicus* in controlled condition.

## MATERIALS AND METHODS

The experiment was conducted in two walk-in plant growth chambers (3.1 m width × 4.7 m length × 2.9 m high) with temperature at 27°C, relative humidity at 70%, photosynthetically active radiation (PAR) level at 55 μmol m<sup>-2</sup> s<sup>-1</sup> and two CO<sub>2</sub> concentrations; 400 ppm and 800 ppm. These chambers were located at MPOB Research Station in Kluang, Johor, Malaysia (1°57.377 N, 103°22.286 E).

Two nearly-anthesised male inflorescences were randomly selected from six year-old DxP palms growing in a nearby field (temperature 26°C, CO<sub>2</sub> 399 ppm and relative humidity 79%). They were covered with terylene bags to prevent from getting

soaked in the rain (Figure 1a). However, the bags were not sealed in order to allow the active weevils to breed in the spikelets.

After three days, the anthesised male inflorescences were sampled between 0900H and 1100H in the morning and brought back to the laboratory (Figure 1b). Three spikelets each from basal, middle and apical regions of the inflorescences were cut and placed in a transparent plastic tube (5.1 cm diameter × 16.5 cm high) (Figure 1c). Both openings of the plastic tube were covered with muslin cloth to ensure good ventilation and to remove any water condensation produced from the spikelets (Figures 1d and 1e). A total of 10 tubes per treatment were placed at an angle of about 15° for better aeration and to drain any water condensation (Figure 1f). The number of emerged weevils was recorded at 10 days after incubation (DAI) in the plant growth chambers. According to Tuo *et al.* (2011), duration of the developmental stages of *E. kamerunicus* is 10.27 days, which includes egg stage, neonate stage, larva stage, nymph stage and adult stage.

## RESULTS AND DISCUSSION

Figure 2 shows the emergence of pollinating weevil at 400 ppm and 800 ppm of CO<sub>2</sub>. The results showed that the number of weevil emerged from the spikelets were low for six DAI, but then rapidly increased after eight days onwards. The number of emerging weevils for both treatments was too high at eight DAI (Figure 3). At Day 10, the weevils were euthanised using a commercial insecticide spray and the number of dead weevils were counted and recorded.

Final counting at 10 DAI showed that the number of weevil emerged in treatments 400 ppm and 800 ppm of CO<sub>2</sub> were 240 and 233 individuals, respectively. They are not significantly different at  $p = 0.05$  between the CO<sub>2</sub> treatments (Table 1). This suggested that the 800 ppm of CO<sub>2</sub> did not affect the weevil emergence under controlled condition.

Other studies have shown that CO<sub>2</sub> can have adverse effect to insects when applied at very high concentration. For example, fumigation using CO<sub>2</sub> can only be effective to kill insects when it is applied at 400 000 ppm for over 7-15 days (Kathleen

TABLE 1. EMERGING WEEVILS RECORDED AT DAY 10 AFTER INCUBATION

	Level of CO <sub>2</sub>	
	400 ppm	800 ppm
3 spikelets (basal, middle and apical) in each tube	240.00 ± 15.93a	233.10 ± 14.56a

Note: Mean ± SE. Values with the same letter are not significantly different at  $p < 0.05$ .

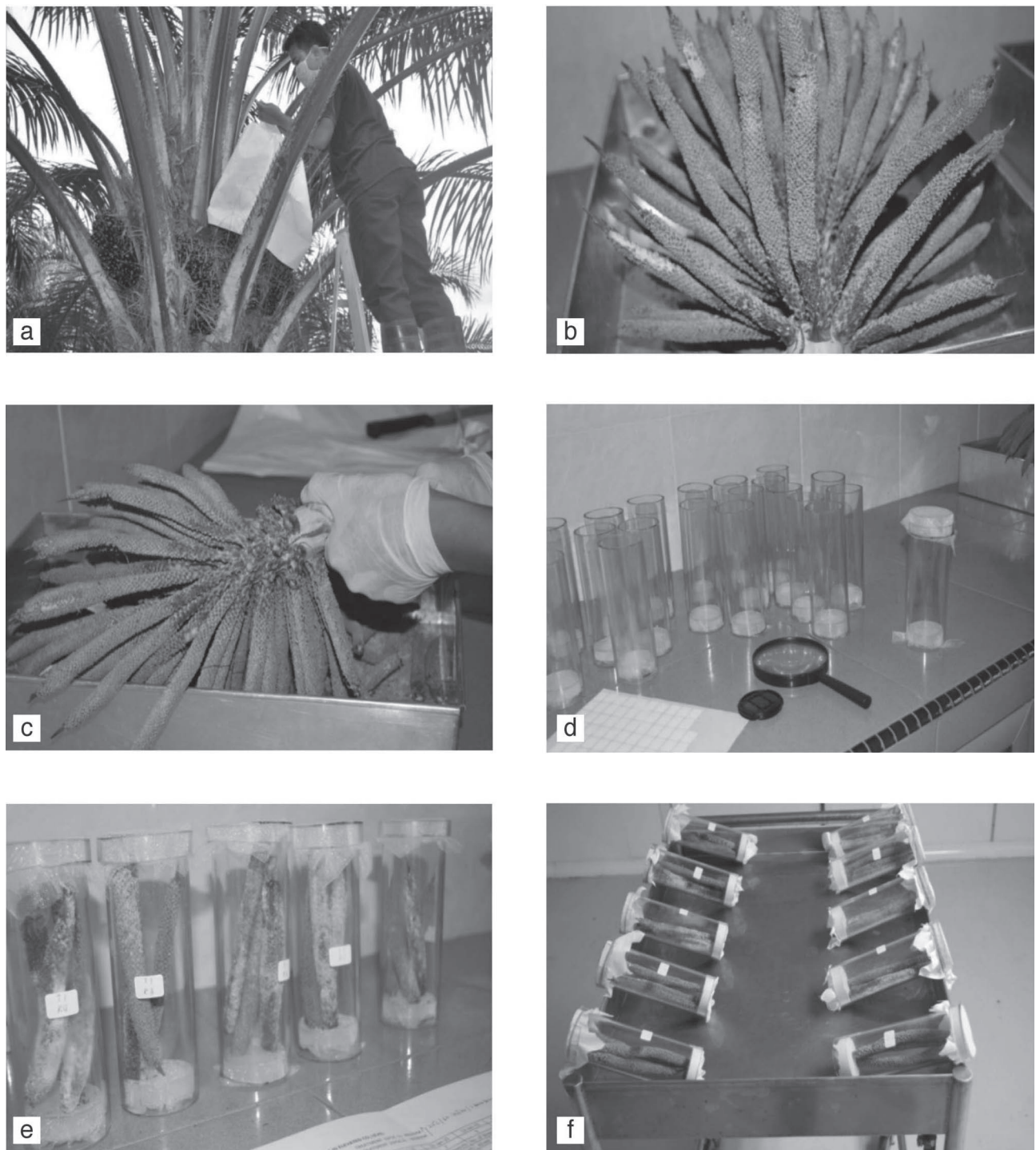


Figure 1. (a) Male inflorescence before anthesis was enclosed in a terylene bag, (b) fresh anthesing male inflorescence was brought to the laboratory, (c) spikelets were taken from apical, middle and basal regions, (d) transparent tubes with their openings covered by muslin cloth were prepared, (e) three spikelets were placed inside the transparent tube and the openings covered with muslin cloth, (f) the transparent tubes were incubated in each plant growth chamber at 27°C, 70% RH and 55  $\mu\text{mol m}^{-2} \text{s}^{-1}$  light level for 10 days.

*et al.*, 1995). If the CO<sub>2</sub> level was kept high and long enough, it would kill all the adults and the offspring that normally hatch several days later. Level of CO<sub>2</sub> greater than 0.5% (5000 ppm) could have adverse health effects to humans, animals and plants (Bardiya *et al.*, 2013).

## CONCLUSION

The emergence of oil palm pollinating weevil, *E. kamerunicus* was not affected when incubated in 800 ppm of CO<sub>2</sub> under controlled environment condition of the plant growth chamber. Further

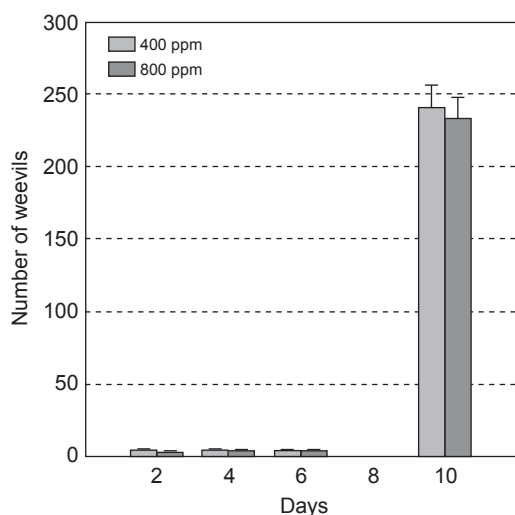


Figure 2. Number of emerging weevils in each tube recorded at two-day interval under the 400 and 800 ppm CO<sub>2</sub> treatments.

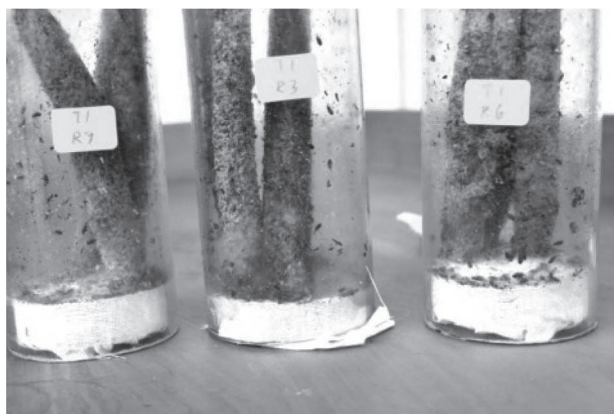


Figure 3. The number of emerging weevils was too high at Day 8 after incubation for both treatments before they were euthanised using a commercial insecticide spray. Then, the number of dead weevils were counted and recorded.

study is still needed to evaluate the effect of high concentration of CO<sub>2</sub> especially on life table and activity of the *E. kamerunicus*.

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