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Use of phenological stages of the fruits and physicochemical characteristics of the oil to determine the optimal harvest time of oil palm interspecific OxG hybrid fruits

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ABSTRACT

Oil palm is the major source of vegetable oil in the world. Traditionally, African oil palm (*Elaeis guineensis* Jacq.) has been used for industrial production, however, in the last few years the interspecific hybrid OxG, a cross between the *E. guineensis* and the American oil palm *Elaeis oleifera* Cortes has emerged as a new alternative for oil palm production, mainly due to the high quality of the oil and the apparent resistance of the hybrid to some of the most problematic diseases. The last is especially true in Latin America where cultivation of oil palm is under pressure from various pests and diseases, particularly the bud rot and lethal wilt, which are a constraint to the sustainability of the crop. However, these interspecific hybrids have problems with fruit filling and ripening due to poor natural pollination and because the flower bud opening is asynchronous. Therefore, it is difficult to determine the optimal harvest time so as to ensure obtaining fruits with the greatest possible amount of oil and with the highest standards of quality. This research identified various physiological, physicochemical and quality parameters to establish the optimal harvest time for fruit bunches. To standardize the optimal harvest time, regardless of the region of cultivation or hybrid used, the different stages of oil palm fruit development were analyzed in accordance with the BBCH phenological scale. The results showed that the optimal harvest time for fruit bunches of OxG interspecific hybrid material (Coari × La Mé) corresponds to the phenological stage 807. The highest values of oil content (21.6%), the lowest free fatty acid values (<1%) and better concentration of phytonutrients were obtained at this stage.

1. Introduction

The African oil palm (*Elaeis guineensis*) is grown in 42 countries, particularly in Asian countries, where Malaysia and Indonesia account for 85% of world production. Colombia is the fifth largest producer. However, Colombia's production is very small when compared with Asian countries, accounting for less than 2% of world production. It is the fastest growing crop in Colombia, with approximately 460,000 ha, of which 65% is in production and the remaining 35% is in the development stage. Colombia is presently the largest producer in Latin America (Fedepalma, 2012)

Unfortunately, diseases such as Red Ring, Ring Spot, Bud Rot (BR) and Lethal Wilt (LW) have greatly affected the African oil palm in Latin America (Torres et al., 2010). This, combined with the fluctuating weather, constitutes a serious constraint to the productivity, profitability and sustainability of the business. Diseases such as BR

Abbreviations: BBCH, Bundesanstalt, Bundessortenamt and Chemical industry scale; BR, bud rot; DAA, days after anthesis; DOBI, deterioration of bleachability index; FFA, free fatty acids; KB, Kernel to bunch; LW, lethal wilt; MBW, mean bunch weight; MF, mesocarp to fruit; MNFW, mean normal fruit weight; MPFW, mean parthenocarpic fruit weight; NFB, normal fruits to bunch; OB, oil to bunch; OB*nf*, oil to bunch from normal fruits; OB*pf*, oil to bunch from parthenocarpic fruits; OFM, *nf*oil to fresh mesocarp in normal fruits; OFM*pf*, oil to fresh mesocarp in parthenocarpic fruits; PFB, parthenocarpic fruits to bunch; SB, shell to bunch; $\sum$SFA, sum of saturated fatty acids; $\sum$UFA, sum of unsaturated fatty acids.

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and LW affect *E. guineensis* plantations regardless of the genetic origin of the material. To date, there is no means of effective control to halt the spread and virulence of those diseases. However, new genetic materials from different crosses with good agronomic prospects have been introduced, which have partial resistance to some pests and diseases as well as greater ability to adapt to the different agro-ecological conditions of the crop (Rocha, 2007)

Some OxG interspecific hybrids, crosses between the American palm *E. oleifera* and the African palm *E. guineensis*, have an apparent partial resistance to the most limiting diseases in the region (Restrepo et al., 2012). Unfortunately, the OxG oil palm hybrids have fruit formation problems, ranging from uneven filling and ripening, because of the asynchronous flower opening, to complete loss of bunches due to poor pollination (López, 1978).

To mitigate these problems in OxG hybrids, several studies have been made, on the morphology and development of the hybrids, from germination up to fruit formation and ripening. These observations were standardized based on the BBCH phenological scale, which helps to produce a more accurate and understandable description of developmental phenomena and crop-related processes (Hormaza et al., 2012).

These previous studies provide a basis for responding to core problems in plantations of OxG interspecific oil palm hybrids such as the determination of the optimal harvest time of fruit bunches so as to maximize oil extraction efficiency in the oil mill and meet the quality standard of the crude palm oil extracted. In the absence of this parameter, the harvesting of bunches was empirically based on the organoleptic characteristics of the bunch (color and texture, fruit cracking, *etc.*), with no agreed consensus among palm growers.

The results presented here comprise a detailed characterization of external (organoleptic) and internal (physical and chemical) developmental changes in the oil palm fruits of an OxG interspecific hybrid cross (Coari × La Mé) in order to determine the optimal harvesting time under the Colombian Eastern Zone conditions, and with potential applicability of these parameters in other oil palm growing areas.

2. Materials and methods

2.1. Materials

The field phase took place between April and December 2010 in the municipality of Barranca de Upía, in the northern part of the Meta Department, located at latitude 4°29′ N and longitude 72°57′ W, altitude 190 m.o.s.l. Table 1 shows the weather conditions during the time of the experiment and the total year where the trial were carried out.

2.1.1. OxG hybrid bunches

The study included 150 OxG interspecific hybrid palms (Coari × La Mé) planted on terraces in 2005 with a spacing of 9.75 m × 9.75 m. A random sample of 21 palms was taken out of a total of 150 palms. Bunches of these selected palms were hand-pollinated. Both, the selection of the inflorescences, and the bunches harvested per palm at different phenological ripening stages were based on the BBCH phenological scale for the OxG hybrid (Hormaza et al., 2012).

For each palm, an inflorescence, located on leaf 20 on average (which based on the phyllotaxis of the palm is located counting from the last leaf opened), was selected taking into account the presence of a ruptured prophyll and a smooth, uncracked peduncular bract, whose characteristics correspond to the phenological stage 509. Subsequently, the time since the flower was on the phenological stage 601 (pre-anthesis I) until anthesis started (phenological stage 607 in which the prophyll has virtually disappeared

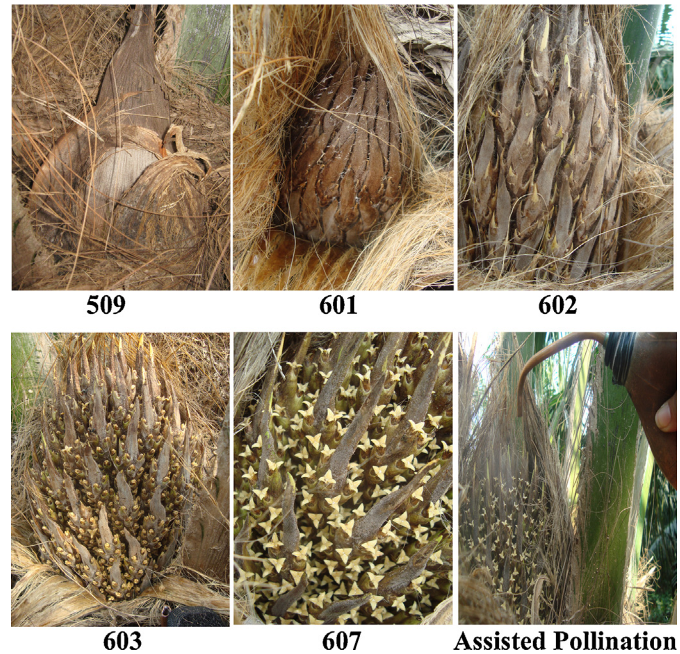

Fig. 1. Internal appearance of inflorescence development stages. Stage 509 (undifferentiated), stage 601 (pre-anthesis I), stage 602 (pre-anthesis II), stage 603 (pre anthesis III), stage 607 (anthesis), and assisted pollination. The phenological stages are based on the BBCH scale for the oil palm OxG hybrids according to Hormaza et al. (2012).

and the peduncular bract breaks) was monitored (Fig. 1). In the field, it was found that this period ranged from 5 to a maximum of 27 days. The assisted pollination was done at stage 607 following the standard procedure of the plantation, using pollen with a germination rate between 72 and 86%, mixed with talcum powder at a mass ratio of 7:1 parts of powder to pollen, respectively.

From here onward, the largest equatorial diameter of the fruit was measured every 7 days *in situ*, using a digital caliper with a resolution of 0.01 mm, to produce growth curves based on days after anthesis (DAA). For this measurement were taken 3 fruits per each one of the apical, middle and basal areas of the fruit. Simultaneously, developing bunches were monitored every day to identify those to be harvested, corresponding to stages 709 (n = 20), 800 (n = 20), 803 (n = 21), 804 (n = 18), 805 (n = 15), 806 (n = 16), 807 (n = 16) and 809 (n = 6) (Fig. 2).

Finally, fruit color quantification was made on photographic images taken in three main areas of the fruit: apical, central and basal, using the software myPANTONE™ palettes version 1.5,

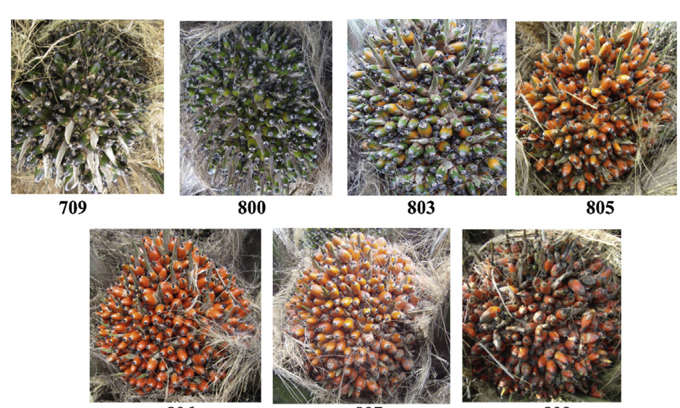

Fig. 2. Bunch development stages of the OxG interspecific hybrid (Coari × La Mé) according to the BBCH scale for the oil palm OxG hybrids (Hormaza et al., 2012).