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Full Length Research Paper

Evaluating postharvest characteristics of Apantu (Local False Horn) plantain for harvest indices determination

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Plantain (Musa *sp*., genome AAB) is a major locally grown starchy staple food highly consumed by Ghanaians with a per capita consumption of 84.4 kg. However, the maturity index of the fruit has been dependent on various characteristics including angularity, fruit tip drying, etc. A physiological study was conducted on the fruit characteristics of Apantu at harvest to determine the appropriate maturity index to be used by smallholders. The results were subjected to correlative analysis and revealed a strong positive correlation between age at harvest and pulp to peel ratio. The number of leaves declined with age while pulp to peel ratio, bunch weight, peel weight and fruit weight showed positive correlation with age. The low correlations observed between the age at harvest and peel thickness, peel weight, density of fruit and pulp thickness makes them unreliable indices, possibly due to the difference in environmental conditions. Generally this is true since smallholders rely upon rainfed irrigation and physiological characteristics are greatly influenced by the watering component of the environmental. It is therefore recommended that farmers use bunch ages to determine harvest maturity. This could be done through tagging of plants at flower emergence due to the strong correlation it had with pulp:peel ratio. Further testing on each variety is needed to make tangible conclusions on some of the maturity indices to be adopted or must be backed with other variables.

Key words: Musa, Apantu, physiology, postharvest, maturity indices.

INTRODUCTION

Plantain (AAB subgroup) is one of the earliest crops domesticated by man and grown in organized agriculture in the humid forest zones of West and Central Africa. Plantain makes up the fourth most important world food item after cereals in terms of the gross value of production. They have been identified to be of great socio-economic and nutritional significance in growing regions (Dzomeku et al., 2011). In the developing world plantain is identified as the fourth most important food commodity after rice, wheat and maize (FAO, 2010,

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Wattanachaiyingcharoen and Boonyanuphap, 2003).

Despite the high value of plantain, poor soils,growing pest threats and disease pressures have affected production, the most notable being the fungal disease - Black Sigatoka (*Mycosphaerella fijiensis*) (IITA, 1992;Stover and Simmonds, 1987; Swennen, 1990). Yield losses due to the disease are highly significant ranging from 20 to 50%. Under very severe conditions yield losses may be as high as 80%. All the plantain landraces in Ghana are susceptible to black Sigatoka disease and other pests except cooking bananas (Dzomeku et al., 2006). The fear that the disease could wipe out the susceptible cultivars, research efforts have been to introduce developed hybrids in readiness for any eventuality. New hybrids, resistant or tolerant to the Black Sigatoka disease were introduced into the country as a long term solution. A large deployment project was executed with four hybrids.

Apantu, a False Horn plantain is the most popular plantain cultivar in Ghana. Apantu cultivation has become a feature of great socioeconomic importance in Ghana from the point of view of food security and job creation. It belongs to the non-traditional sector of the rural economy, where it is used mainly to shade cocoa and is also an essential component of the diet. More than 90% of the cultivated area in Ghana belongs to smallholder farming system. In the agricultural sector, plantain is ranked fourth in Ghana (FAO, 2010) and contributes about 13.1% to the Agricultural Gross Domestic Product (AGDP). Its per capita consumption of 84 kg (SRID-MOFA, 2010) is higher than all other starchy staples. A total of 359,865 ha of land area in Ghana is used to cultivate plantain producing an annual average of 3.7 million tonnes of fruits, of which more than 95% is sold on the domestic market (SRID-MOFA, 2010). Apantu production is concentrated in the three agro-ecological zones namely rain forest, moist semi-deciduous forest and forest-savanna transition. The rainfall pattern is bi-modal from March to July as the major rainy season and August to November as the minor season. Although Apantu plays a significant role in the farming systems in Ghana, there has not been any conscious effort to develop any maturity indices for the crop. Maturity indices of plantain under rainfed production could be unreliable as they are often influenced by the environment. Physical, biochemical and physiological parameters are used to define the maturity stage for harvesting of fruits (Jha et al., 2006). Huda (2003) and Robinson and Saúco (2010) described that the banana fruits having the stage of three quarters round was considered as commercial maturity. The common maturity indices used by most plantain farmers for assessing for harvest in view of the absence of universal criteria, are any combination of the following: (i) By experience and judged largely by the visual appearance of the hanging bunch and particularly by the angularity of individual fingers (Palmer, 1971). (ii) Fruits harvested when the fingers of the first hand on the bunch show signs of ripening or yellowing or when the finger tips turn black (Dadzie, 1994b, c). (iii) In commercial plantations, fruits destined for distant markets are harvested at a stage known as 'three quarters full', when the fingers are still clearly angular. For local markets fruits are often harvested when fingers are full or rounded (iv) Usually coloured ribbons are used in commercial plantations to provide information regarding bunch age. (v) Fruit diameter (or caliper grade of fruit) and fruit length may be used as criteria to determine when to harvest (Dadzie and Orchard, 1997). Dadzie and Orchard (1997) stated again that while it is advantageous if the maturity index is non-destructive so that every fruit can be evaluated, it is important that the indices can be measured in a rapid, simple and inexpensive way (Reid, 2002). The method of evaluation should be simple and easily replicable, not requiring any complex scientific methodology so that farmers with basic literacy in mathematics can evaluate their plantain production and maturity time. In other jurisdictions, various instrument based techniques are used to measure maturity and ripeness. It is important to note that if the fruits are very mature at harvest, particularly following a heavy rain, peel splitting can occur.

It is evident that under rainfed conditions, the maturity indices are influenced by the environment. In the dry season angularity may be deceptive as an index of maturity. Also the soil nutrient and soil moisture could also influence the maturity indices. The objective of this study therefore was to critically evaluate the physiological characteristics of Apantu with maturity indices.

MATERIALS AND METHODS

Field samples of Apantu (False-horn) plantain were harvested at 5-day intervals of 70 to 105 days after flower emergence. The fruits were harvested from the Crops Research Institute plantain orchard at Fumesua near Kumasi in the rainy and dry seasons. Data was taken on 20 plants and replicated three times. In all, a total of 480 plants were harvested from the orchard. The field is located at 1° 31'W and 6^{o} 43'N. The soil type is the sandy-loam (Aeronosols). The annual rainfall ranges between 1400 and 1700 mm. Annual temperature range of 22 to 33°C can be recorded on this field all year round.

In this study, 60 plants per maturity were tagged at flower emergence to determine their age after flowering. At sampling ages fresh samples were harvested in the cool of the morning to conform to postharvest standards of keeping the fruit at a minimum achievable temperature to preserve harvest quality before reaching the pack house, market or the consumer. This study was carried out on the field right after harvesting and continued in the laboratory before any deterioration. Studies were carried out within 48 h of harvesting. The methods of Dadzie and Orchard (1997) and Gowen (1995) were used. All measurements were limited to the fingers of the second hand on each bunch sampled. However, when there were not enough samples, the third hand was included. Some agronomic data were recorded prior to harvesting to assess any correlation between them and observations at harvest. Some of these were; (a) plant height; (b) pseudostem girth; (c) number of functional leaves; (d) bunch weight; (e). total number of fingers, and (f) number of hands.

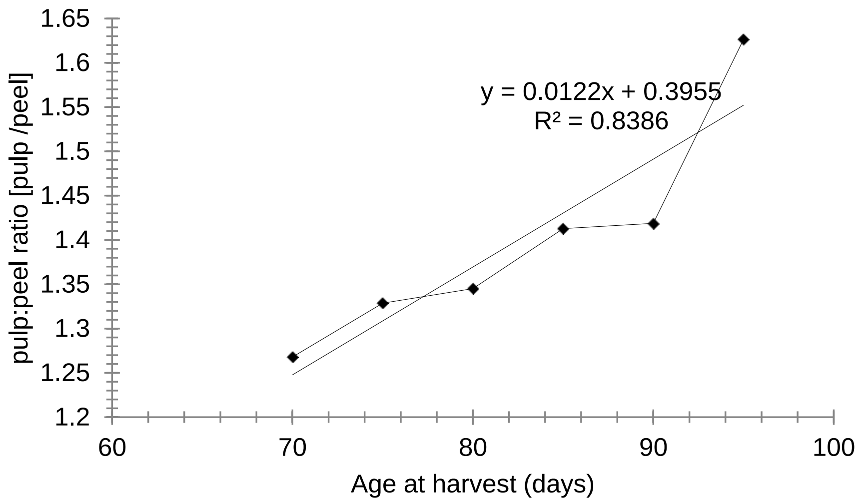

Figure 1. Relationship of pulp: peel ratio of Apantu with Bunch age.

At harvest, bunch weight was determined by weighing individual bunches with a balance. Number of hands was obtained by counting the number of hands on each bunch. Number of fingers was obtained by simply counting the number of fingers (per hand) on each bunch. Fruit weight was determined by weighing individual fruit on a weighing scale. Fruit length was determined by measuring the outer curve of individual fruit with a tape measure from the distal end to the point at the proximal end where the pulp is judged to terminate. Fruit girth or circumference was determined by measuring individual fruit with a tape measure at the widest midpoint of each fruit. Volume of fruit was obtained by direct volume displacement or by weighing fruit under water (Kushman and Pope, 1968; Kushman et al., 1966). Pulp and peel weight were determined after fingers have been hand-peeled and peel and pulp weighed separately with Mettler electronic balance usually to 2 decimal places). Pulp and peel were separated, weighed individually and expressed as pulp to peel ratio. Hand peeling of each fruit after cutting transversely at the midpoint was done, and the peel and pulp separately measured with a pair of calipers.

The data was subjected to ANOVA and the standard deviation was emphasized to reveal or reduce significant errors between duplication.

RESULTS AND DISCUSSION

Maturity indices must meet two requirements for producers, locations and seasons (years): (i) Minimum acceptable eating quality, and (ii) Long storage life (Dadzie and Orchard, 1997).

The False Horn plantain fruit diameter recorded throughout the year ranged between 33.4 and 44.2 mm.
They all fall within the minimum acceptable limits indicating that all were mature for consumption and compliant to African standards. With visual observation of fruit angularity, the ages at which fruits were harvested displayed significant change from angular, at 70 days after flower emergence (AFE) to rounded, at 95 days AFE, a visual indication of maturity.

There was a positive correlation between pulp-to peel ratio and bunch age (Figure 1). This corroborated well with the results of Dadzie and Orchard (1997) on hybrid cooking bananas as the ratio of pulp to peel increases with age at 1.27 (70 days) to 1.63 (95 days); a strong indicator of increasing maturity and readiness for harvest. The only challenge with the use of this index is the destructive approach. A finger must be removed from the bunch to determine if the requirement is met. This approach could serve as an entry point for pathogens as a wound would be created in the process of removal of the finger. However, smearing of petroleum jelly to prevent entry of pathogens through the wounded portion is recommended.

There was a decline in the number of functional leaves as the fruit approached maturity (Figure 2). This was not surprising as this is directly linked to translocation of nutrients as into fruits during fruit -filling as well as the high susceptibility of the landrace to diseases. The most destructive of these diseases being Black Sigatoka caused by *M. fijiiensis* as indicated by Dzomeku et al. (2006), IITA (1992).

The relationship between age and the weight of the fruit (Figure 3), showed a clear increase possibly due to the fruit filling. Plantain is a determinate plant and after flowering, the physiological process of nutrient translocation is for fruit filling. There is also translocation of photosynthase into the fruit without any new leaf production. Evidence shows that fruit filling is a critical stage of the plantain crop when abiotic factors can influence the yield. Turner and Thomas (1998) reported that, plantains are sensitive to soil water deficits; expanding tissues such as growing fruit are among the first to be affected.

Bunch weight weakly correlated to number of fingers (Figure 4). The varying growth and developmental differences of the various fingers translated into physiological difference manifested in the weights. The environmental conditions under rainfed systems often

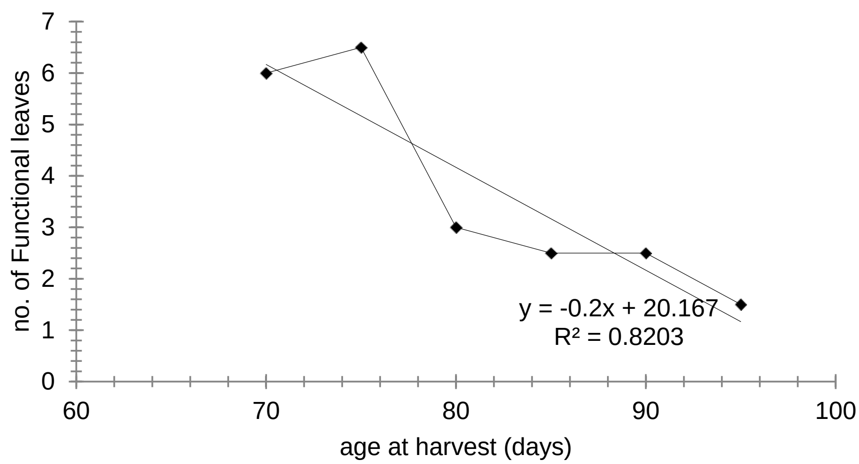

Figure 2. Relationship of functional leaves of Apantu with maturity.

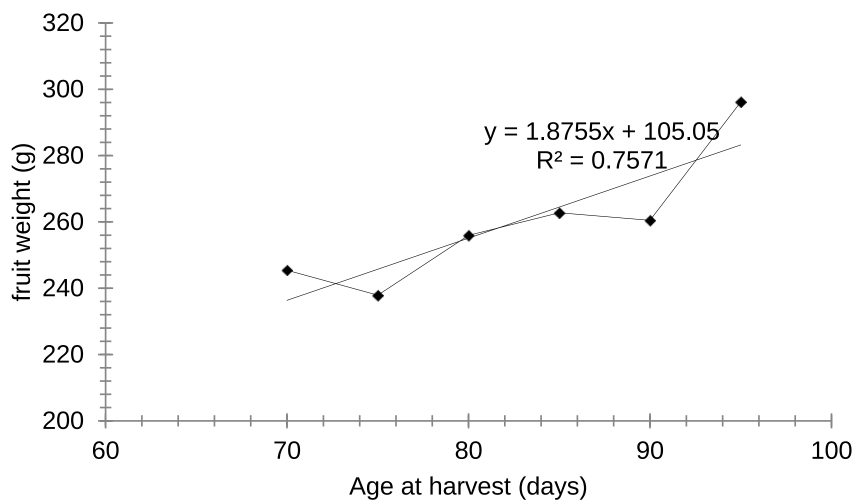

Figure 3. Relationship of fruit weight to bunch age of Apantu.

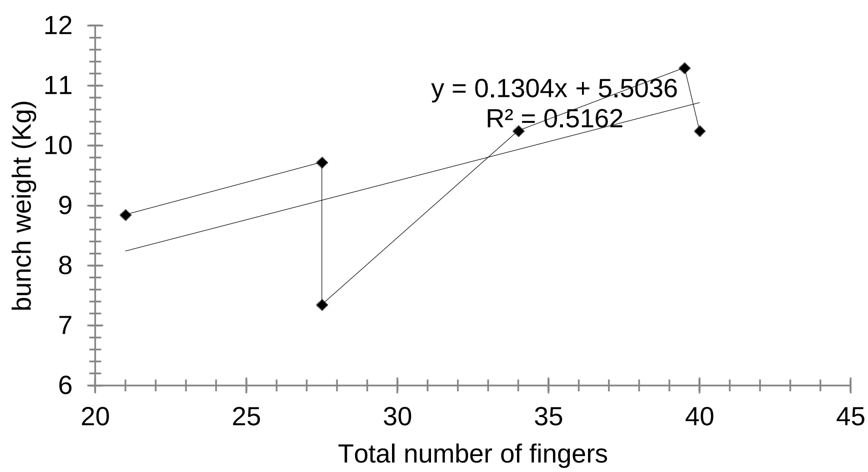

Figure 4. Relationship between number of fingers and bunch weight of Apantu.

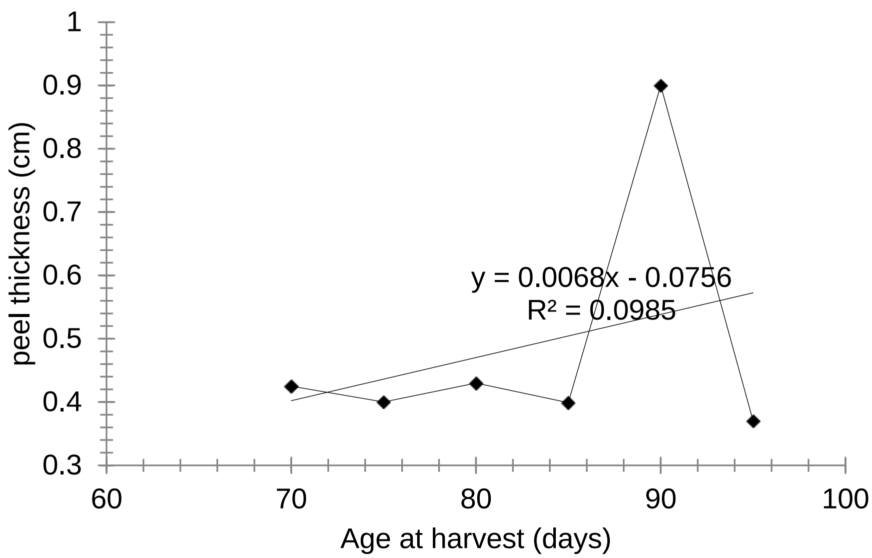

Figure 5. Correlation between bunch maturity and peel thickness of Apantu.

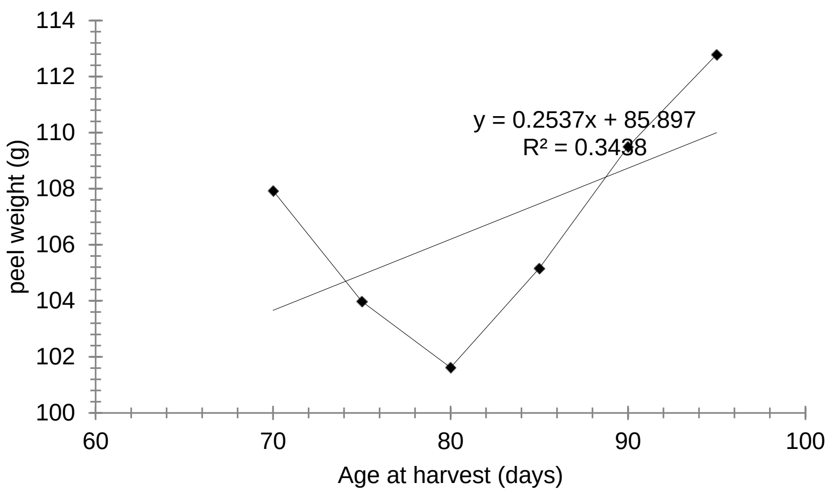

Figure 6. The relationship between bunch maturity and peel weight of Apantu bunches.

show variations. It has been observed that the number of hands on a bunch as well as the number of fingers could be influenced by soil nutrient and rainfall.

There was a low correlation observed between the ages at harvest and peel thickness (Figure 5). This correlation does not make the parameter a reliable maturity index for Apantu. There is normally a decline in fruit density due to the reduction of its displacement power (weight) and this was reflected in the test. The low correlations observed between the age at harvest and peel thickness, peel weight, density of fruit and pulp thickness makes them unreliable indices (Figure 6).

They can, however; be indicators of other environmental conditions within which the fruit grew. Most of these parameters are cultivar dependent and as such cannot be blindly compared to other cultivars in literature. The study has shown that rainfed plantain production cannot in anyway bring about the full potential of the crop. Productivity is affected because of the erratic nature of the rain coupled with the soil nutrient. The critical stage of growth of the crop is at flowering. Water deficit at flowering severely affects fruit filling. Plantains (*Musa* spp.) rarely attain their full genetic potential for yield due to limitations imposed by water limiting the plants photosynthesis. Plantains are known to be particularly sensitive to changes in the environment. Plantain growth and yield is known to decrease drastically when the interval between watering was increased with the soil moisture falling below 66% of total available soil moisture (Robinson and Bower, 1988). Under severe soil moisture stress, physiological and biochemical processes occur. Physiologically stomata close and this affects photosynthesis. It is worth noting that if the fruit is too matured at harvest, particularly following a heavy rain, peel splitting can occur. In the commercial banana industry, maturity is estimated through fruit diameter which differs with the standards used the world over; a difference that may be expressed in the following ways: (a) Total thirty-seconds of an inch (e.g. grade 42 which is 110/32 inch); (b) The number of thirty-seconds of an inch above thirty-two (e.g. grade 10 which is 110/32 inch); (c) Millimeters (e.g. grade 42 is 33 mm using 0.794 for each thirty-second of an inch). In Central and South America, grade is expressed as the number of thirty-seconds of an inch above 1, whereas millimeters are used in the Caribbean and Africa (Stover and Simmonds, 1987). It is evident that under rainfed conditions these parameters may vary according to the seasons. During the major harvesting seasons (June to February) angularity would be a very pronounced index unlike in the harvesting months of March to May.

Conclusions

The peel to pulp is the singular most important indicator of fruit maturity that can be used on the field. However due to its destructive nature, it cannot be extensively used. In combination with the other parameters measured, the age of bunch is the most reliable stand-alone parameter and is recommended for extensive promotion and use by smallholder farmers.

Conflict of Interests

The authors have not declared any conflict of interests.

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