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Exploring the Growth and Development of Rambutan (*Nephelium lappaceum* L.) Seedlings: The Impact of Fruit Maturation on Seed Germination, Seedling Growth and Biomass Partitioning

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ABSTRACT

Background: Rambutan (*Nephelium lappaceum* L.) is one of the most important tropical commercial fruits widely cultivated in south-east Asia, Australia, South America and African countries due to its nutritional value. However, in Ghana the fruit is gaining popularity in many households and, this could serve as an alternative source of income. The experiment was conducted at the CSIR-Plant Genetic Resources Research Institute, Bunso, Eastern region-Ghana. The objective of the study was to evaluate the effects of maturity stages on Rambutan seed vigour, germination, seedling growth and biomass partitioning.

Methods: Fruits of three maturity stages (*i.e.* green, half-ripe and fully ripe) were harvested from the field genebank and seeds were extracted and sown immediately after harvest. The experiment was arranged in a randomised complete block design in three replicates.

Result: The results showed that fully ripe fruits had better seed vigour, seedling growth and biomass partitioning followed by the half-ripe fruits. Fruits harvested at the green stage showed the least performance.

Key words: Biomass partitioning, Maturity stage, Rambutan, Seed vigour, Seedling growth.

INTRODUCTION

Rambutan (*Nephelium lappaceum* L.), belongs to the family Sapindaceae and it includes other fruit crops such as litchi, longan and pulasan. It is native to several tropical regions of Southeast Asia, such as Malaysia and Indonesia, but its commercial cultivation has expanded to as far as Australia, India, Madagascar, Philippines, Singapore, South Africa, Syria, Thailand, Vietnam, Congo (Ampthill, 2010). The fruit is edible and has an attractive and acceptable flavour. The pulp is said to contain an array of vitamins and antioxidants. A 100 g of rambutan fruit contains sucrose (10 g), energy (297 KJ), potassium (14 mg) and vitamins (70 mg). The leaves and skin of the fruit are used as a dye and also some tongue diseases can be treated with the bark (Abbey, 2000). The wood is hardwood and is used for construction purposes.

The cultivation of fruit tree crops of nutritional and medicinal value is crucial for both the economy and the health and well-being of Ghanaians. The introduction of exotic fruit tree crops like rambutan which have the potential to grow well in Ghana presents a wide range of new options for the selection of economically important crops for production. According to Andrade *et al.* (2008), there is a search by producers and consumers for these new options, among which rambutan presents high market potential. According to Tindall (1994) and Nakasone and Paull, (1998), commercial production of Rambutan trees increased foreign exchange earnings in tropical Australia, central and southern parts of Africa and South America. Records from Plant Genetic Resources Research Institute indicate that it was first introduced into Ghana in the 1960s but until recently, adoption for cultivation was very low. Between 2019 and 2021, 6, 250 rambutan seedlings were produced and sold to farmers for plantation establishment (CSIR-PGRRI, 2020). It is estimated that the demand for rambutan seedlings in Ghana will increase as Ghanaians get to know the health and economic importance of the crop. Besides, rambutan is known to have export potential thus could be one of the major export crop for Ghana after cocoa.

Rambutan can be produced using seeds or by vegetative means. However, the use of seeds for commercial propagation is challenged by the fact that the sex of

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rambutan seedlings produced by seed can be male, female, or hermaphrodite. Notwithstanding, the seed plays a major role in rambutan propagation. Rambutan has propagation challenges such as the quality of seeds used. Given that in Ghana, information is critically absent concerning rambutan propagation there is a need to identify the best physiological stage for harvesting rambutan fruits for raising good quality seedlings for orchard establishment. The objective of this experiment was to fill the gap by assessing the impact of physiological seed maturity on seed germination, seedling growth and biomass partitioning of rambutan.

MATERIALS AND METHODS

Fruits of rambutan (*Nephelium lappaceum* L.) were obtained from the CSIR-Plant Genetic Resources Research Institute field genebank (N 06°17.839, W 000°27.595, Alt 198.3 m above sea level), Bunso, Eastern Region, Ghana during the harvesting season in July 2020. Rambutan fruits, the yellow-red cultivar were harvested at three physiological maturity stages. These comprised green, half-ripe and fully ripe fruits (Fig 1).

Thirty rambutan fruits each at different maturity stages were harvested and sown in polybags of dimension 15.5 cm × 20.5 cm filled with topsoil with a pH (6.56), electrical conductivity (170.57 µS cm^{-1}), organic carbon (2.18%), total nitrogen (0.16%), available phosphorus (16.43 mg kg^{-1}), exchangable potassium (0.196 $cmol_c$ kg^{-1}), exchangable magnesium (0.843 $cmol_c$ kg^{-1}) and exchangeable calcium (4.511 mol_c kg^{-1}). The experiment was arranged in a randomised complete block design in three replicates.

Seeds sown were watered daily and kept under shade trees. During seedlings establishment, insect pests were controlled using a systemic insecticide, K-optimal (Landa-cyhalothrin 15 g/l +Acetamiprid 20 g/l: EC) at a recommended rate of 40 ml to 15 L of water at two weeks intervals.

The seed vigour (first count) was established on the 14th day after seed emergence. Percentage seed emergence was computed at 21 days after sowing as a ratio of the total number of seeds that emerged to the total number of seeds sown multiplied by 100.

The growth of rambutan seedlings was assessed by the number of leaves and plant height in centimeters at monthly interval after seed emergence for a period of six months.The plant height was measured using a metre rule. Plant biomass determination was carried out using four rambutan plants from each treatment and replicated 3 times. Sampled plants were washed to remove debris and separated into roots, stems and leaves for the determination of plant dry mass. Samples were oven-dried at 80°C for 72 hours and weighed using an electronic balance. The total plant dry mass was calculated as the sum of the root, stem and leaf masses. The root-to-shoot ratio was calculated from the aboveground and belowground masses.

Statistical analyses were conducted using SPSS Statistics 21 (IBM, Chicago, IL, USA). One-way ANOVA was used to test the effects of treatments. When a significant difference was detected, Tukey's HSD test was performed to identify significant differences among maturity stages.

RESULTS AND DISCUSSION

Effect of maturity stage on seed vigour and germination of rambutan

The effects of maturity stage on seed vigour and germination of rambutan is shown in Fig 2 and 3. Maturity stage had a significant difference in seed vigour with no difference in germination percentage. Fruits harvested at the fully ripe showed the highest seed vigour at days after germination followed by the half-ripe fruits. However, rambutan fruits harvested at the green stage recorded the least vigour. Rambutan seed vigour increased steadily after emergence in the maturity stages. Although seeds harvested at different maturity stages germinated by 21 days, fruits harvested at the green stage had the least vigour. However, with fleshy fruits, there is disagreement as to the appropriate time for harvesting to obtain good-quality seeds. Melo (2005) reported that the ideal time for harvesting is when the fruit is fully ripe. Besides, Carvalho and Nakagawa (2000) recommended harvesting of fruits soon after the beginning of maturation, when the colouration continues to be green. Mazorra and Quintana (2003) found a high percentage of germination (over 90%) in seeds from the fruit of a greenish-yellow colour 50 days after fruiting. According to Carvalho and Nakagawa (2000), physiological maturity is reached when the seed presents maximum dry matter content and also a marked reduction in water content, changes which are visible in the external appearance of the fruit and seeds, culminating in maximum seed germination and vigour. Alexandre *et al.* (2006) in their studies on three different

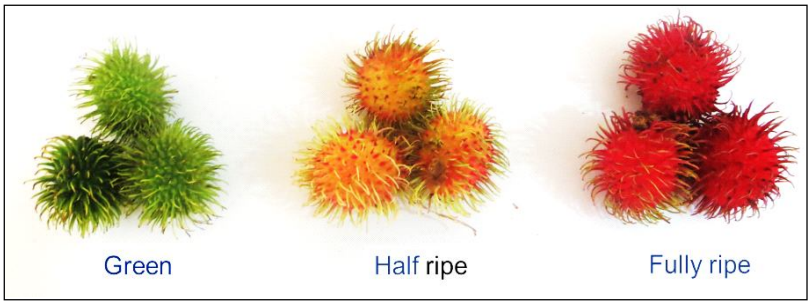

Fig 1: Rambutan fruits harvested at different maturity stages.

stages of maturation in the germination and development of seedlings of jabuticaba (*Myrciaria cauliflora*) observed that the stages of maturation did not significantly influence seed germination. However, a low germination percentage at the start of fruit development is attributed to seed immaturity. This is because the protein which is responsible for reserves in the seed is probably not adequately synthesised. According to Mazorra and Quintana (2003), maturity in Physalis fruit is reached 50 days after the start of fruiting (yellowish-green calyx and fruit), when over 90% germination is seen and the fruit acquires features that guarantee seed propagation and later development. Perhaps, the observed differences in seed vigour could be attributed to seed immaturity.

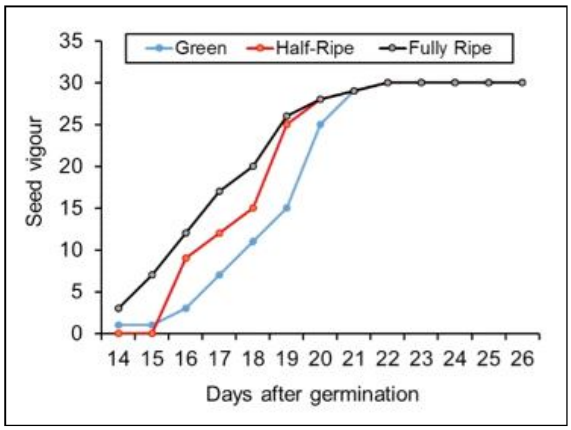

Fig 2: Effect of maturity stage on rambutan seed vigour.

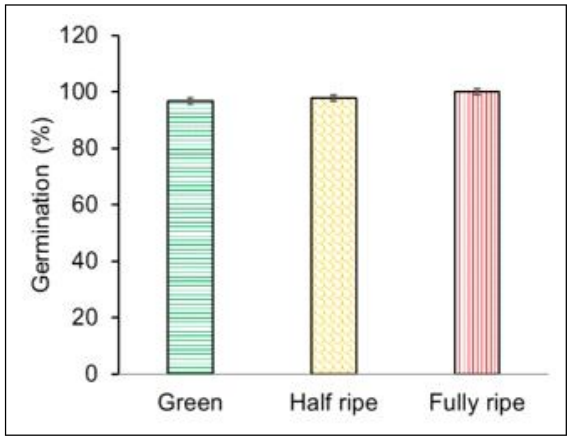

Fig 3: Effect of maturity stage on rambutan germination.

Effect of maturity stage on plant height and number of leaves of rambutan

Fig 4 and 5 show the effects of maturity stage on plant height and the number of leaves per rambutan plant. The maturity stage had no significant difference on the number of leaves and plant height at 1, 3 and 4 months after germination. There were significant differences in plant height at 2 months after germination. The fully ripe fruits obtained the highest plant height at two months after germination while fruits harvested at the green stage had the lowest plant height. Meneguzzo *et al.* (2021) reported differentiation of seedling growth and development as a result of the vigour levels of seed lots. In agreement with our findings, seeds extracted from fruits harvested at the fully ripe stage showed the highest vigour. This indicates that fully ripe fruits cultivated under field conditions may withstand adverse climatic conditions in early seedling establishment. Finch-Savage and Bassel (2016) in their studies reported that the efficiency of resource use depends on successful plant establishment in the field and it is the vigour of seeds that defines their ability to germinate and establish seedlings rapidly, uniformly and robustly across diverse environmental conditions.

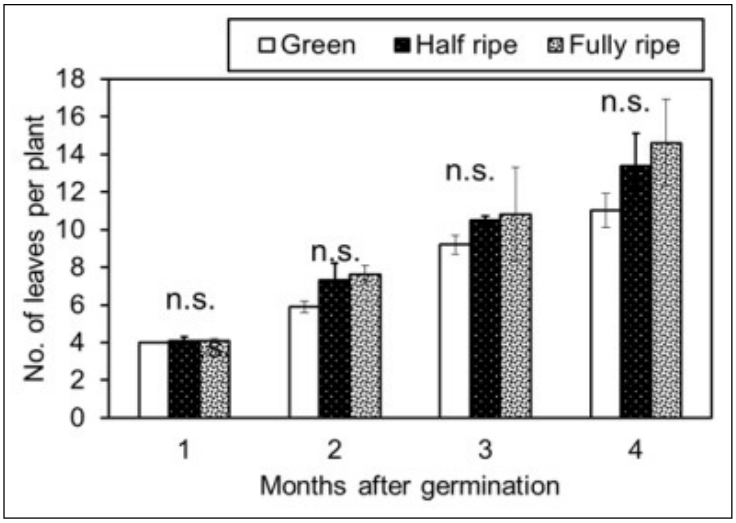

Fig 4: Effect of maturity stage on the number of leaves per plant of rambutan. One-way ANOVA: n.s.: not significant.

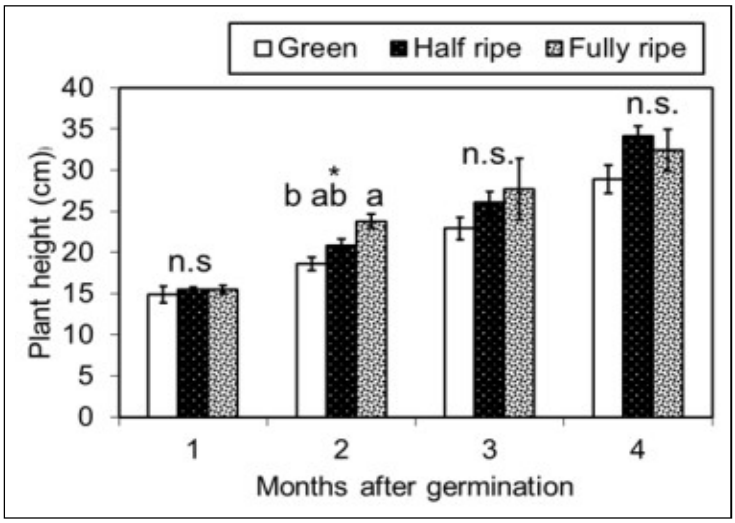

Fig 5: Effect of maturity stage on plant height of rambutan. Values with different letters are significantly different at p<0.05.

Table 1: Effect of maturity stage on rambutan plant dry mass.

Treatment	Dry mass (g)				Root/shoot ratio
	Leaf	Stem	Root	Total	
Green	2.39	1.47	1.15^{b}	5.01^{b}	0.30
Half Ripe	2.87	1.94	1.27^{ab}	6.08^{ab}	0.27
Fully Ripe	3.07	1.96	1.38^{a}	6.41^{a}	0.27
Significance	n.s.	n.s.	*	*	n.s
P-value	0.099	0.210	0.045	0.040	0.595

n.s. = Not significant. *Significant at p<0.05. Values with different letters are significantly different at p<0.05 of Turkeys HSD test.

Effect of maturity stage on rambutan plant dry mass

The effect of maturity stage on the leaf, stem, root and whole-plant dry masses and the R/S ratio of rambutan are shown in Table 1. Significant differences (p<0.05) were observed in root and total rambutan plant biomass. Leaf, stem and root-to-shoot ratios did not differ significantly. The root dry mass of fully-riped was significantly higher than the half-ripe and green fruits. The lowest root and total rambutan biomass were observed in fruits harvested at the green stage. Mašková and Herben (2018) reported that the ultimate success of a seedling depends on the development of its own resource acquiring organs (leaves and roots), but also how well they can respond to the ambient environment, using the predictable maternal resources of all nutrients in the seed. Root growth is critical to the establishment of planted seedlings. Seedlings can undergo stress just after planting if root growth is not sufficient to couple the seedling to available soil water. In our study, seeds extracted from fully ripe fruits showed higher root dry mass than seeds extracted from the half-ripe and green fruits. The observed differences could be used in selecting seeds for nursery establishment for stress conditions to enhance nutrient use efficiency and adaptation. Future research should focus on response of rambutan seedlings raised from fully ripe fruits under shade and different fertilizer types for better growth and development.

CONCLUSION

In conclusion, maturity stage of rambutan fruits significantly affects seed vigour and plant growth. Fully ripe fruits showed the highest seed vigour and plant height, as well as greater root and total plant biomass compared to half-ripe and green fruits. However, there was no significant difference in germination percentage among fruits harvested at different maturity stages. The findings suggest that selecting seeds from fully ripe fruits can enhance nutrient use efficiency and adaptation of seedlings under stress conditions. The results provide valuable insights for improving nursery establishment practices and optimizing seedling performance in rambutan cultivation.

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Conflict of interest: None.

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