Morphogenesis of the tuberization of two varieties of yam (*D. cayenensis-rotundata*): attempt to understand the precocity of var. kponan

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ABSTRACT

Yams exhibit variations in dormancy break, which could be responsible for the early maturity of certain varieties. The objective is to understand the origin of the early maturity of the Kponan yam variety. This was studied through morphological observation of tuberization during the first month and monitoring until tuber maturity. Two varieties, Kangba and Kponan, belonging to the species *Dioscorea cayenensis-rotundata*, were used. An experimental field was set up in 20 cm x 20 cm nursery bags. For monitoring purposes, the mass and length of the tuber were determined. Early emergence was sometimes observed 10 days ± 1 after planting. Most emergence ranged from 22 days ± 2 to 35 days ± 5 for the Kponan variety. For the Kangba variety, seeds without buds on the day of planting showed emergence 34 days ± 3 to 45 days ± 2 after being placed in bags. Early emergence was observed at 27 days in two plants. From the date of emergence in the field, the first visible sign of tuberization in the Kponan variety appears between 48 ± 4 and 57 ± 3 days. For Kangba, this period ranges from 48 ± 2 days to 71 ± 4 days after emergence in the field. The earliness of the Kponan variety is due to the dual earliness of field emergence and tuber initiation.

Keywords: Tuber, tuber growth, yam, morphology, nursery bag

1. INTRODUCTION

The yam is a climbing plant belonging to the genus Dioscorea and the monocotyledonous class. The plant consists of two main parts: the aerial part, consisting of foliage, and the underground part, consisting of roots and tubers. The tuber is a storage organ rich in starch and certain micronutrients. The presence of these nutrients: lipids, fiber, vitamin, alkaloids, sterols, steroids, proteins, carbohydrates, cardioglycosides, and terpenoids has been reported by these authors as well as by micro (Fe, Cu, Mn, Zn, Mb, and Cl) and macro minerals (K, Cl, P, Ca, Mg, and Na). Depending on the nature of its constituents, the yam tuber can be used for food or medicinal purposes. The species *D. opposita*, widely cultivated in China, is prized in traditional medicine for its therapeutic properties (**Ge et al 2023; Cui et al 2023; Tareen et al 2025**). In West Africa, most of the species cultivated are used for food. These varieties, which are very rich in starch, are suitable for traditional dishes such as fufu, foutou, mash, frying, and others (**Obidiegwu 2020; Singh and Twinkle 2022**). The yam therefore constitutes an essential source of food, employment, income and a vital component of food security in the region (**Zangoma et al 2025**).

The yam tuber contains within it, a functional dynamism responsible for its evolution from initiation to the next dormancy break, passing successively through stages of growth, maturity, and dormancy. During the growth phase, the histological study conducted by Degbeu et al. 2019 showed the existence of a longitudinal growth gradient whose point of growth is the apex and the sense of maturity of the distal part at the proximal end. The cambium generates cells at the lower end of the apex. These very vacuolated cells differentiate and will form the median and proximal parts of the tuber. This cambium generating activity would cease when the tuber become matures. The existence of this gradient has an impact on the technological suitability of the different parts of the yam tuber. Thus, the suitability for cooking decreases from the proximal part to the distal end. Firmness and dry matter decrease from the proximal part to the distal end of the tuber (**Brunnschweiler, 2004**).

At maturity, the tuber enters a period of dormancy, defined as the period during which endogenous metabolic activity is reduced and there is no intrinsic bud growth, although it retains the potential for future growth (**Ile et al 2006, Nwogha et al 2022**). The duration of dormancy depends on the species, storage conditions, weather conditions and the degree of maturity of the tuber or the time of tuber harvest (**Hamadina 2011; Nwogha 2022; Zangoma et al 2025**). In general, D. alata varieties have a long dormancy period (three to four months) compared to those of D. cayenensis-rotundata (one to one and a half months) (**Craufurd et al 2001; Wickham 2019**). Early varieties harvested in August begin to break dormancy in January. This is four to five months after harvest. Once dormancy is broken, the shoot develops, producing leaves and branches, leading to the plant's volubility. At the same time, the underground roots develop and the mother tuber that gave rise to the plant begins to degenerate (**Trouslot 1985**).

The initiation of tuberization is identified by the appearance of “suber bursting” at the base of the stem in plants propagated by tuber fragments. In yam plants grown from seed, the initiation of tuberization is manifested by a bulge located between the starting point of the main root and the base of the first scale leaf of the main axis (**Trouslot 1985**). Micro-plant studies have shown that the Microtuberization is affected by plant growth regulators such as Naphthalene acetic acid, gibberrellic acid and jasmonic acid (**Balogun 2006; Hamadina et al 2010**).

Since dormancy breaking is the first stage in the natural regeneration process of the tuber, its variability could impact the second stage, which is the initiation of tuberization. This is the research hypothesis of the present study, the objective of which is to understand the origin of the precocity of the Kponan yam variety. In this study, the morphological aspect of tuberization of two yam varieties (Kponan and Kangba) of the species *Dioscorea cayenensis-rotundata* was analyzed. The Kponan variety is early maturing and the Kangba variety is late maturing.

2. MATERIAL AND METHODS

2.1 Materiel

The kangba and kponan varieties of yam, belonging to the species Dioscorea cayenensis-rotundata, were used as plant material. The fragmentation process produced pieces of yam with an average mass of 137.3 ± 35.6 g for the kponan variety and 93.5 ± 28.9 g for the kangba variety. For this study, the head of the tuber was avoided as much as possible to ensure uniformity of emergence. The seedlings are at the end of dormancy, i.e., at the beginning of germination. Most of them have a bud characteristic of dormancy emergence. Three samples with shoots measuring 2.5 cm, 3 cm, and 12 cm, respectively, were observed for the kponan variety

2.2 Methods

2.2.1 Setting up the plots

The field was created at Nangui Abrogoua University on an area of 50 m². The land is fallow soil. During periods of low or no rainfall, the plants were watered once or twice a week as needed. The bags were filled with forest soil enriched with pig manure. The stakes used were Chinese bamboo placed between the rows of bags. The bags were used to ensure the even distribution of soil nutrients and to allow each plant to have the same nutrients. The seeds were planted in 20 cm x 20 cm nursery bags and arranged in rows 1 m apart, with 0.5 m between bags. After the yams were bagged, the field was visited weekly to monitor "field emergence," i.e., the appearance of the bud above the mound (Trouslot, 1985), in this case the bag. Once the bud has appeared above the bag, the date is recorded and will serve as a reference point for monitoring tuberization.

2.2.2 Sampling technique

The tubers were harvested at different times by cutting them with a stainless-steel knife. This allows the tuber to be separated from the pre-tuber. The tubers were harvested at the beginning of tuberization at the stage when the suber bursts, which is the first visible sign of tuberization (day 0; day 7; day 15; day 30 and day 40). Monitoring then took place from the 16th week after the seeds were bagged until the 26th week, i.e., weeks 16, 18, 20, 22, 24, and 26. Week 26 corresponds to the onset of leaf yellowing. At each harvest period, the size of the tuber was measured using a Mitutoyo caliper (Braive Instrument, Belgium) and the mass was determined using a Scaltec scale (Heiligenstadt, Germany).

3. RESULTS

3.1 Sprouting period of yam cutting after planting and tuber initiation

Three cutting samples of Kponan had buds measuring 2.5 cm, 3 cm, and 13.3 cm, respectively, or 1, 3, and 6 scale leaves on the day of planting on 20 plants of the Kponan variety. For these three samples, growth resumed 16, 9, and 6 days after planting, respectively. The emergence period for these three plants appears to be scattered. This represents an average of 10 days ± 5. Most emergence ranges from 22 days ± 2 to 35 days ± 5. Late emergence 56 days after planting was observed (**table 1**). For the Kangba variety, cutting without buds, on the day of planting, show emergence 34 days ± 3 to 45 days ± 2 after being placed in bags. Early emergence was observed at 27 days in two plants.
From the date of emergence in the field, the first visible sign of tuberization in the Kponan variety appears between 48 ± 4 and 57 days ± 3. Unlike the emergence period in the field, the bursting stage is not dispersed. The average is around 53 days ± 5. Plants with late emergence initiate tuberization earlier, at 32 days after emergence in the field. For the kangba variety, this period extends from 48 ± 2 days to 71 days ± 4 after emergence in the field. This period is longer compared to observations made on the kponan variety ($p < 0.05$).
In general, after planting on April 14, 2007, suber bursting appears from 71 days ± 5, or 10 weeks to 86 days ± 3 (12 weeks) in the kponan variety. In the kangba variety, this period is around 95 days ± 4 after planting, or 13 weeks.

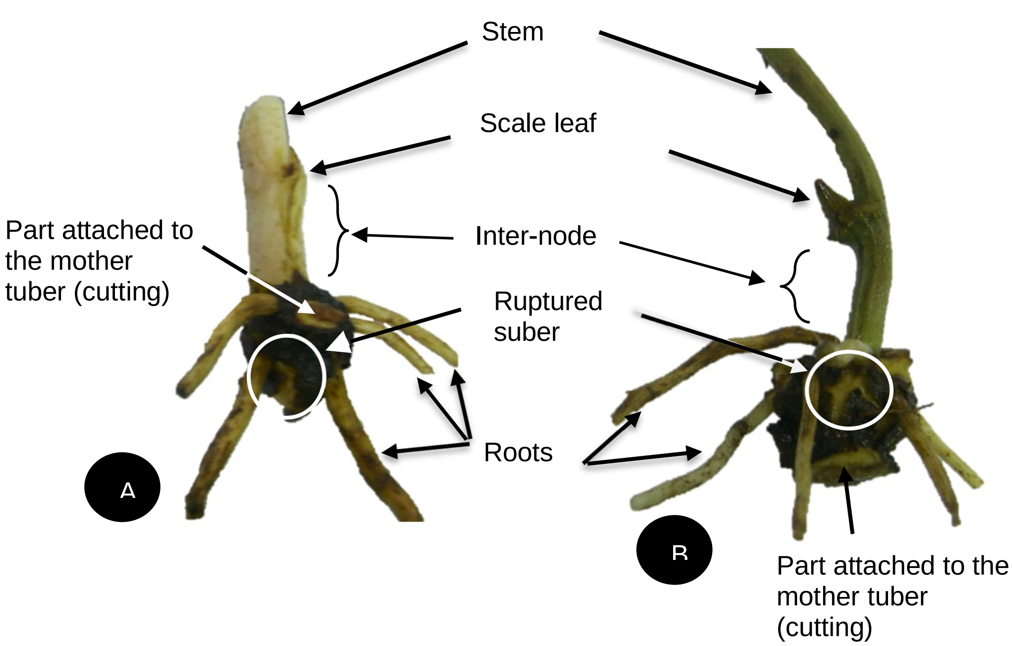
Table 1: Sprouting period of yam cutting and tuber initiation

varieties	Appearence of sprouting (number of days)	Tuber initiation	Planting date-tuber initiation
Kponan	10 days ± 5 (3 budding plants)	57 days ± 3	71 days ± 5 to 86 days ± 3
	28 days ± 1 (2 ungerminated plants)	55 days	
	22 days ± 2 (6 ungerminated plants)	53 days ± 7	
	35 days ± 5 (5 ungerminated plants)	48 days ± 4	
	56 days (1 ungerminated plants)	32 days	
Kangba	27 days (2 ungerminated plants)	71 days ± 4	95 days ± 4
	34 days ± 2 (7 ungerminated plants)	62 days ± 5	
	43 days ± 2 (7 ungerminated plants)	50 days ± 3	

	45 days ± 2 (4 ungerminated plants)	48 days ± 2

3.2 Development of the emerging tuber

The first visible sign of tuberization is the rupture of the suber covering the base of the stem (Fig. 1A and 1B). Over the following days, the bursting spreads as the proliferation of the underlying tissue intensifies. The suber disintegrates and disappears under the effect of this proliferation at the apical end of the tuber (Fig. 1C and 1D). At the beginning of tuberization, new roots appear. These roots have a white membrane that is not suberized, unlike the first roots. From the 7th day onwards, a tuber bud is visible (Fig. 1C and 1D). The base of the stem begins to develop into a new tuber or neo-tuber, while the mother tuber (cutting) shrinks (Fig. 1A) and eventually degenerates (Fig.1B). It will form the pre-tuber at harvest.
In the Kponan variety, the onset of tuberization is accompanied by total degeneration of the yam cutting. This is not the case with the Kangba variety, where the rest of the seed is still visible. The yam cutting of the Kangba variety has simply shriveled. In addition, the arrangement of the new roots differs between the two varieties. In Kangba, the new roots appear on the new tuber (Fig. 1C). This is not the case with the Kponan variety (Fig. 1E). Seven days after the start of tuberization, the new tuber of the latter has a bulbous shape characteristic of a tuber. In the Kangba variety, however, the arrangement of the new roots on the new tuber is characteristic of a woody mass. The apical end of the developing tuber is light yellow in both the Kponan and Kangba varieties. It is covered with a cap.
From the seventh day onwards, the organ thus formed hypertrophies longitudinally and radially to produce a more rounded tuber on the 21st day (Figs. 2A and 2B). Three weeks after the start of tuberization, the mother tuber disappears completely. The protrusion at the base of the stem is more intense at the apical end and is responsible for the tuber's grown significantly in length. This results in a cylindrical-conical tuber with a rounded and slightly tapered apical end, reflecting the predominance of apical meristem activity. As the tuber's growth in length intensifies, suberization of the outer layer or skin of the yam can be observed at the proximal end. The intensity of this suberization decreases from the proximal part toward the distal end. Suberization is more pronounced in the Kponan variety at the proximal part of the tuber at 18 weeks after planting (Fig. 2C). It extends to the entire tuber at 22 weeks after planting (Fig. 2E). In the Kangba variety, suberization begins in the proximal part at 18 weeks after planting (Fig. 2D). However, this phenomenon is more visible at 22 weeks after planting (Fig. 2F). The distal end remains unsuberized.



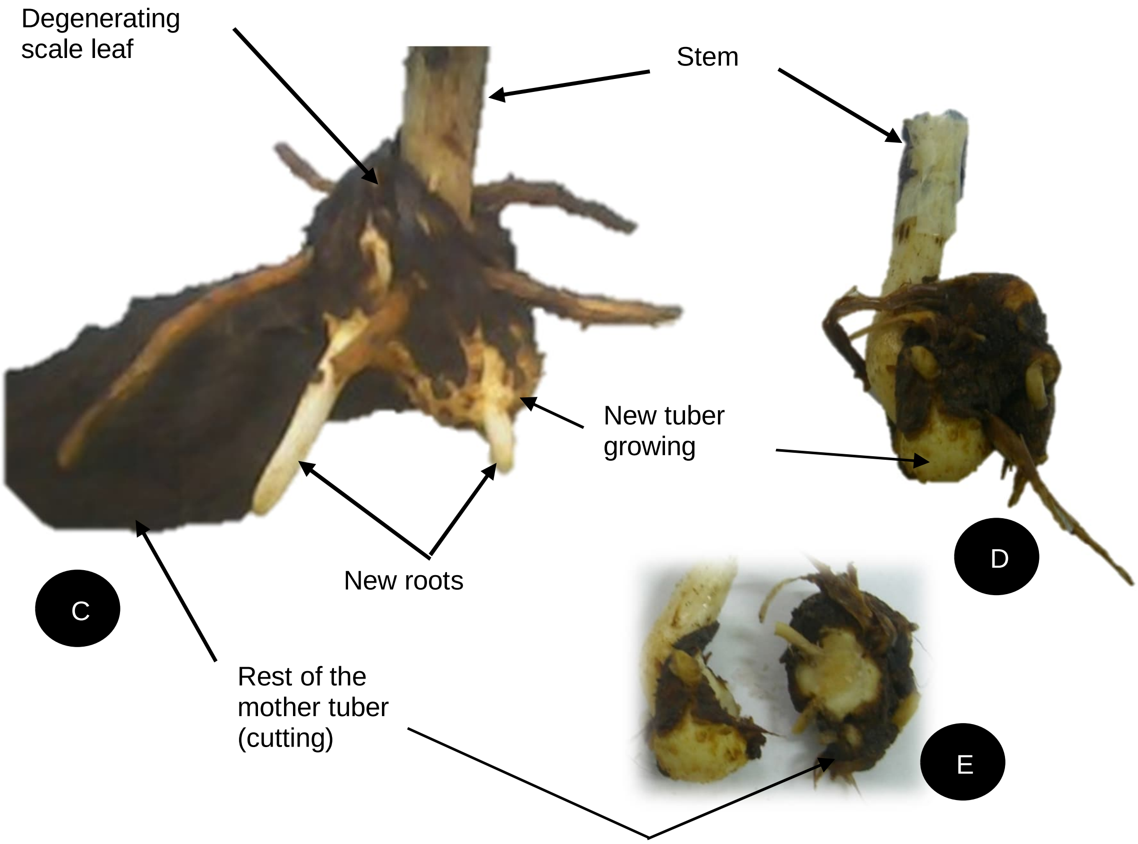
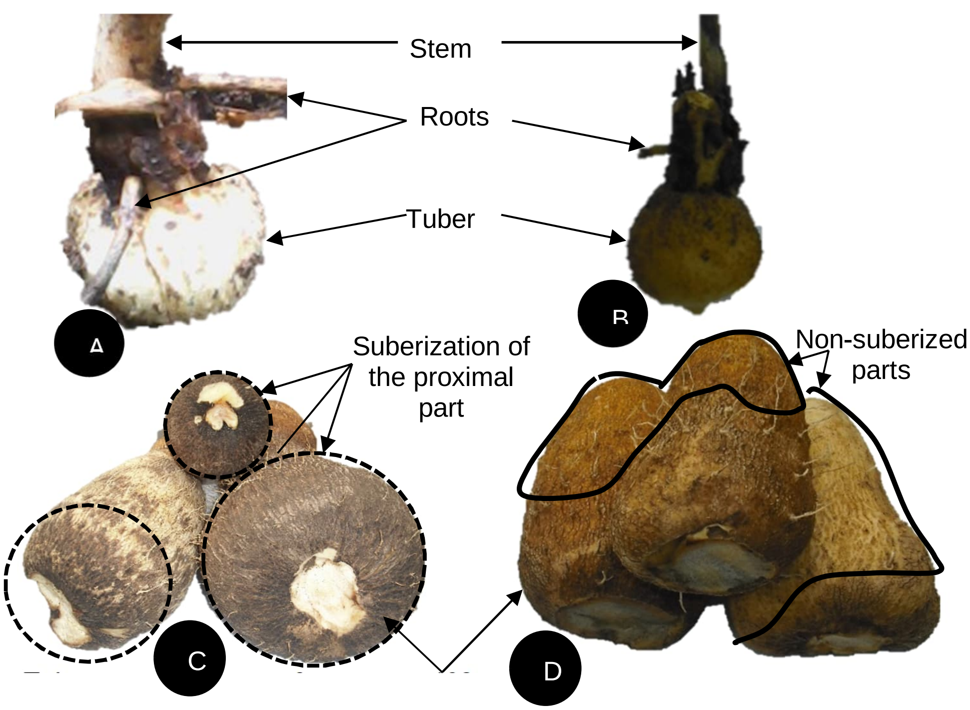


Fig. 1. Earlier stage of tuberization. The tuber initiation is materialized by the rupture of the suber (A, B). The following days, the protuberance of meristem cells lead to the tuber formation and growing observable seven days after rupture of the suber (C, D). The cutting is observable for var. kangba (C), not for var. kponan (E). Scale bars: 1 cm



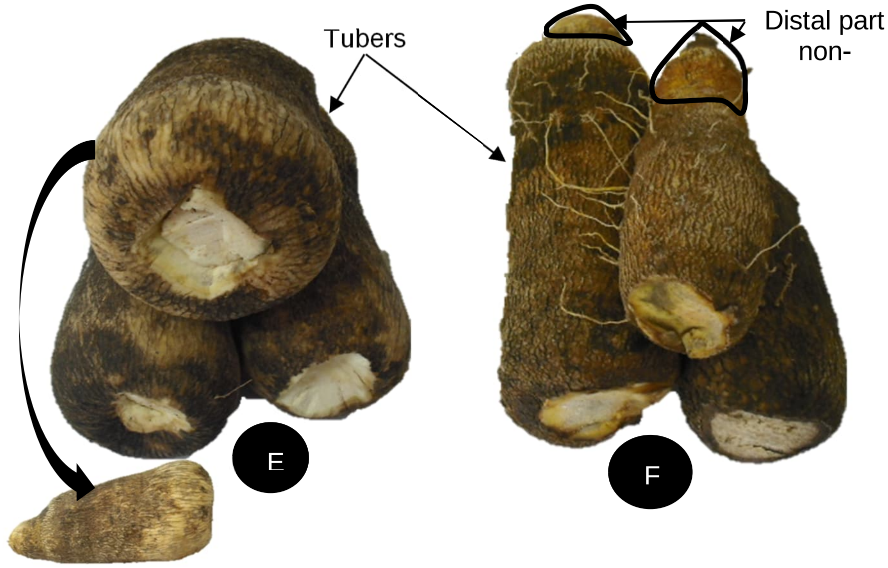


Fig. 2: Yam tubers at different stages of maturity. A, B are respectively tubers of. var. Kponan and Kangba at twenty-one days after the rupture of the suber. C and E are tubers of var. Kponan at respectively eighteen and twenty-two weeks after the cutting were bagged. D and F are tubers of var. Kponan at respectively eighteen and twenty-two weeks after the cutting were bagged.

3.3 Evolution of the size and mass of the emerging tuber

From the seventh day onwards, the mass of the tuber formed is around 1.56 ± 1.2 g and 1.35 ± 0.1 cm in length (Kponan variety) (Table 2). The Kangba variety has approximately the same mass and size (1.47 ± 1.1 g A; 1.2 ± 0.3 cm). Two weeks after the start of tuberization, the mass of the Kponan variety tubers is higher than that of the Kangba variety. From the 21st day after the start of tuber initiation, the mass of the tubers was greater in the Kponan variety (15.3 ± 4 g to 36.25 ± 5.3 g). The size remained the same.

Table 2: Changes in tuber mass and length over 40 days after the suber burst stage

varieties	Days	Mass (g)	Length (cm)
	7	1,56 ± 1,2	1,35 ± 0,1
	15	4,5 ± 1,8	2,02 ± 0,2
Kponan	21	15,3 ± 4	3,2 ± 0,3
	30	36, 25 ± 5,3	5,2 ± 1,4
	40	121,5 ± 26,6	9,4 ± 0,11
	7	1,47 ± 1,1	1,2 ± 0,3
	15	3,18 ± 1,3	2,1 ± 0,1
Kangba	21	10,45 ± 3,4	3,02 ± 0,5
	30	31,73 ± 5,1	4,6 ± 1,8
	40	114,49 ± 13	12,3 ± 2

3.4 Changes in tuber weight and length from the sixteenth week after planting

The evolution of tuber length and mass was monitored starting in the second month after the first visible sign of tuberization appeared, i.e., 16 weeks after planting (Fig. 3A). Tuber growth, which began in the first few weeks after the suber burst, intensified until the 22nd week after sowing, i.e., three months after the start of tuberization. From this period onwards, tuber growth slowed down and tended to stabilize until the 26th week after planting. The growth of kponan yam tubers is greater until the 17th week. Beyond this period, the length growth of kangba tubers becomes more significant, until tuber growth stops at the 26th week. As for the evolution of tuber mass (Fig. 3B), it becomes significant from the 20th week onwards. This increase in tuber mass tends to stabilize from the 24th week onwards for the kponan variety. For the kangba variety, tuber mass continues to increase even beyond week 26. Comparison of the average tuber mass of the two varieties shows a significant difference ($p < 0.05$).

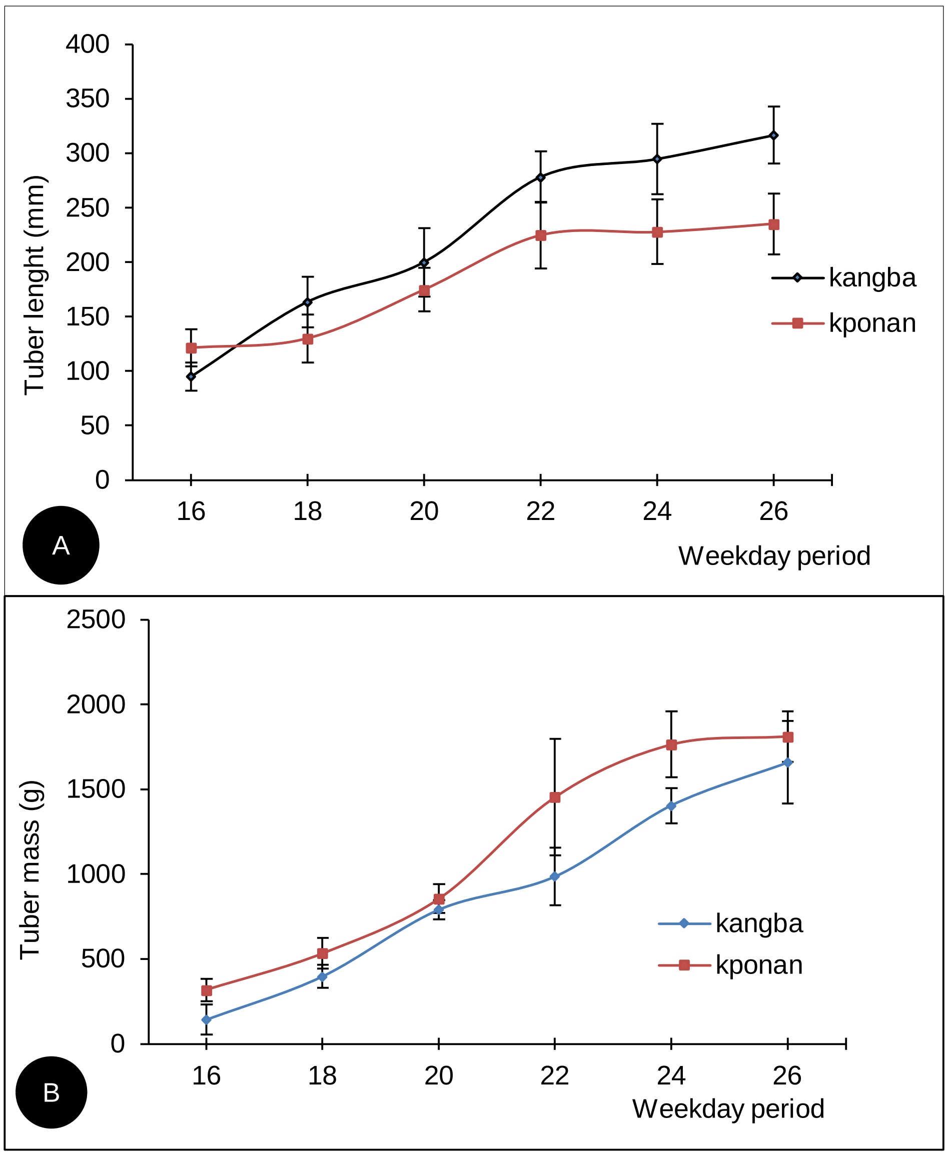


Fig. 3: Changes in tuber length and mass during tuberization. A) Tuber length; B) Tuber mass

4. DISCUSSION

The development of the tuber was monitored from the emergence of the main stem above the bag to the formation of the tuber. The three plants bearing a bud on the day of planting indicate a resumption of stem growth 6 to 16 days after planting, or an average of 10 days ± 5. The resumption of stem growth depends on the level of development of the preformed bud. Based on observations, the more developed the bud, the earlier the resumption of growth. However, in practice, shoots that are too long are removed by farmers, as the tuber bearing the bud would be weakened by excessive depletion of its reserves (**Trouslot 1985**). The period of dormancy in the field for most yam cuttings of the two varieties Kponan (22 to 35 days) and Kangba (34 to 43 days) falls within the range (14 to 91 days) reported by **Hamadina (2011**). This period varies greatly according to previous studies and is influenced by regulatory hormones (**Nwogha 2022; Zangoma et al. 2025**). Cuttings of the Kponan variety germinate quickly compared to those of the Kangba variety. This could be due to varietal differences (**Wickham 2019**). In in vitro yam stem fragment cultures, tuberization begins after three weeks under normal conditions and one week when phytohormones are used (**Jova et al., 2011**). From the date of planting to the initiation of tuberization, cuttings of the Kponan variety tuberize quickly compared to those of Kangba. This could partly explain the earliness of the Kangba variety. Visual observation of the onset of tuberization also shows that the tuber used as a cutting disappears in Kponan, while it is still present in the Kangba variety. This could also explain the earliness of Kponan. Similarly, the fiber content of the mother tuber could have an impact on the earliness of tuberization initiation. Fiber-rich tubers such as Kangba tend to shrivel, thus delaying this phenomenon. Those of the Pkonan variety, being less fibrous, rot quickly and tuberize sooner. The same applies to morphological observations of the different stages of tuberization, where the tuber becomes corky earlier in the Kponan variety than in the Kangba variety. However, suberization is characteristic of tuber maturity, based on observations. At 22 weeks after planting, the tubers of the Kponan variety are completely suberized, while those of the Kangba variety show a growing distal end. The Kponan variety produces early tubers that are larger in mass than those of the Kangba variety. The Kponan yam tuber is morphologically shorter and has a larger diameter than the Kangba tuber, which would explain, on the one hand, the higher position of the Kangba variety on the length growth curve and, on the other hand, the higher mass of the Kponan variety tubers.

4. CONCLUSION

Generally speaking, after planting on April 14, 2007, the suber bursts after 71 days ± 5, or 10 weeks for the Kponan variety, and 95 days ± 4 (13 weeks) for the Kangba variety. The mass growth of tubers of the Kponan variety is stronger than that of the Kangba variety. The Kponan variety initiates tuberization and early maturity compared to Kangba.

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