

Can *Kponan* Yam (*Dioscorea cayenensis*) Full Season Tuber Sprout If Planted?

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Abstract: In a completely randomized blocks (RCB) plot, we planted seed from the three segments of *Kponan* tubers: head, median and tail portions with control *Krengle*. Germination began 10 d and lasted 67 d. The mean sprouting rate of the *Kponan* full season harvest tuber was 78.1% compared to 94% in *Krengle*. However, the tuber germination was progressive from head to tail with a linear evolution of the top fragments with sprouting rate up to 90% similar to *Krengle*. The median and distal portions sprout two and three weeks later with final raising rates reaching 68% and 71%, respectively. The full season tuber of *Kponan* sprouts with a good rate gave good yields for any portion of the tuber. It had a sprouting gradient oriented from the proximal portion to the distal one, while yield was better for medium seeds. The sprouting delays two weeks between proximal and medium portions and three weeks between proximal and distal portions were acceptable with regards to the total cycle of eight to nine months period. Thus, its small tubers could be planted as well as the top portion of big tuber. In terms of yield, *Kponan* medium seed gave the best yield 34.25 t/ha and the whole *Kponan* tuber yield was more than *Krengle*. That led to a better multiplication factor for *Kponan* full season tuber. The type of tuber, if available, could be used as seed for yam production. That could improve its distribution and contribute to food security.

Key words: Yam, full season harvest, sprout, tuber yield, multiplication rate, Côte d'Ivoire.

1. Introduction

In West Africa, four yam species (*D. alata*, *D. dumentorum*, *D. bulbifera* and *D. esculenta*) are grown, in addition to the cultivated complex *D. cayenensis-rotundata*, predominant in this area [1].

Yam is the most important food crop in Côte d'Ivoire in terms of production volume with more than three million tons produced annually. Production comes from two groups of species: the *Dioscorea alata* group with more than 60% of the yam cultivated area [2] and the *Dioscorea cayenensis-rotundata* that occupies almost of the total remaining area. In this complex, there are two main groups according to the harvest period: early yams with double harvest periods

and late yams characterized by a single harvest (full season). In the early yam group, the first harvest from July to September gives tubers for consumption while the second harvest (December-February) is used for seed material.

Yam is an organic matter demanding plant. Intensive agriculture with fallow, organic matter supplementation is usually required. Yam has relatively long cycle, and organic matter helps to reduce chemical fertilizer uses.

Early-maturing varieties, harvested five to six months after plantation, offer consumption tubers for three to four months period almost. As a result, the minimum duration of conservation, to ensure good annual distribution of needs, is eight months that must be covered with late yams. On the other hand, it is known that in yam production, unexpected

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post-harvest losses fluctuate between 25% and 60% [3-5], reducing the production.

The production of yams in Côte d'Ivoire is experiencing the same constraints as in the entire West African production zone from Côte d'Ivoire to Cameroun. These are soil fertility losses, non-use of fertilizers, poor quality of seed, high parasite pressure and limited production potential of traditional varieties [6]. As a result, yam production has remained at the same level for more than two decades with yields of the order of 8 t/ha to 10 t/ha. Also, cultivation is characterized by very low planting densities practised only in rainy season [7].

For market and consumption, *Kponan* is the preferred variety. Harvested five to six months after plantation, it offers consumption tubers for three or four months period almost from July to October and it is completely unavailable from February up to June. To improve this short consumption period, some producers maintain a part of their field for a full season harvest from December to January. So tubers harvested have an added value. Theoretically, mature edible and cultivated yams do not contain toxins. However, bitter principles tend to accumulate in the immature tuber of *D. rotundata* Poir and *D. cayenensis* Lamk and the immaturity increases losses.

Yam tuber dormancy can be influenced by its physiological age. This term is used to define the stage of development of seed tubers [8]. According to Wiltshire and Cobb [8], it is primarily influenced by cultivar, growing conditions and the harvest period. Studies showed that tubers harvested before complete maturity had a dormancy period longer than those harvested at the mature state [9]. Natural dormancy period varies from four to 18 weeks according to the variety.

In Côte d'Ivoire, there is no structure for "seed" production and producers collect "seed" material in harvested yams for late yams such as *D. alata* and some *D. rotundata* varieties. Seed yam for early varieties like *Kponan* is derived only from the second harvest tubers

since farmers consider that tubers from the first harvest have no sprouting capacity.

These tubers are also difficult to store beyond 10 weeks because of their immaturity and indeed, such immature tubers do not sprout if planted. Farming needs a significant improvement of seeds production methods to develop low-cost production. The performance of the genus *Dioscorea* is directly dependent on the planting date and the variations of environmental factors. The main purpose of this paper is whether full season tubers of an early variety like *Kponan* sprout in order to formulate best practices for its edible tubers.

2. Materials and Methods

2.1 Site Location

Kponan single harvest tuber germination test was performed at the University Jean Lorougnon Guédé in Daloa Department (Fig. 1). Experimental site was located at 6.91130° N, 6.43826° W and 285 m altitude.

2.2 Planting Material

Seeds yam was bought at the market according to farmers practice and a full seasonal production made in order to have single harvest tubers for the experience. In a completely randomized blocks (RCB) disposal, we tested full season tubers ability to sprout if planted. Full season tuber of *Kponan* was divided in three portions: head, medium and tail (Fig. 2), each being planted in a unit plot with four replicates. The *Krengle* variety was used as control.

2.3 Planting

Seeds were cut into fragment of 150 g to 200 g and treated with ash and decis during 2 h, and let to dry in the shade before planting on April 15. According to Kpemoua and N'kpenu [10], the best caliber of seed varies between 100 g to 200 g.

The parameters observed were the first sprout date, emergence rate and the germination delay. Soil has been

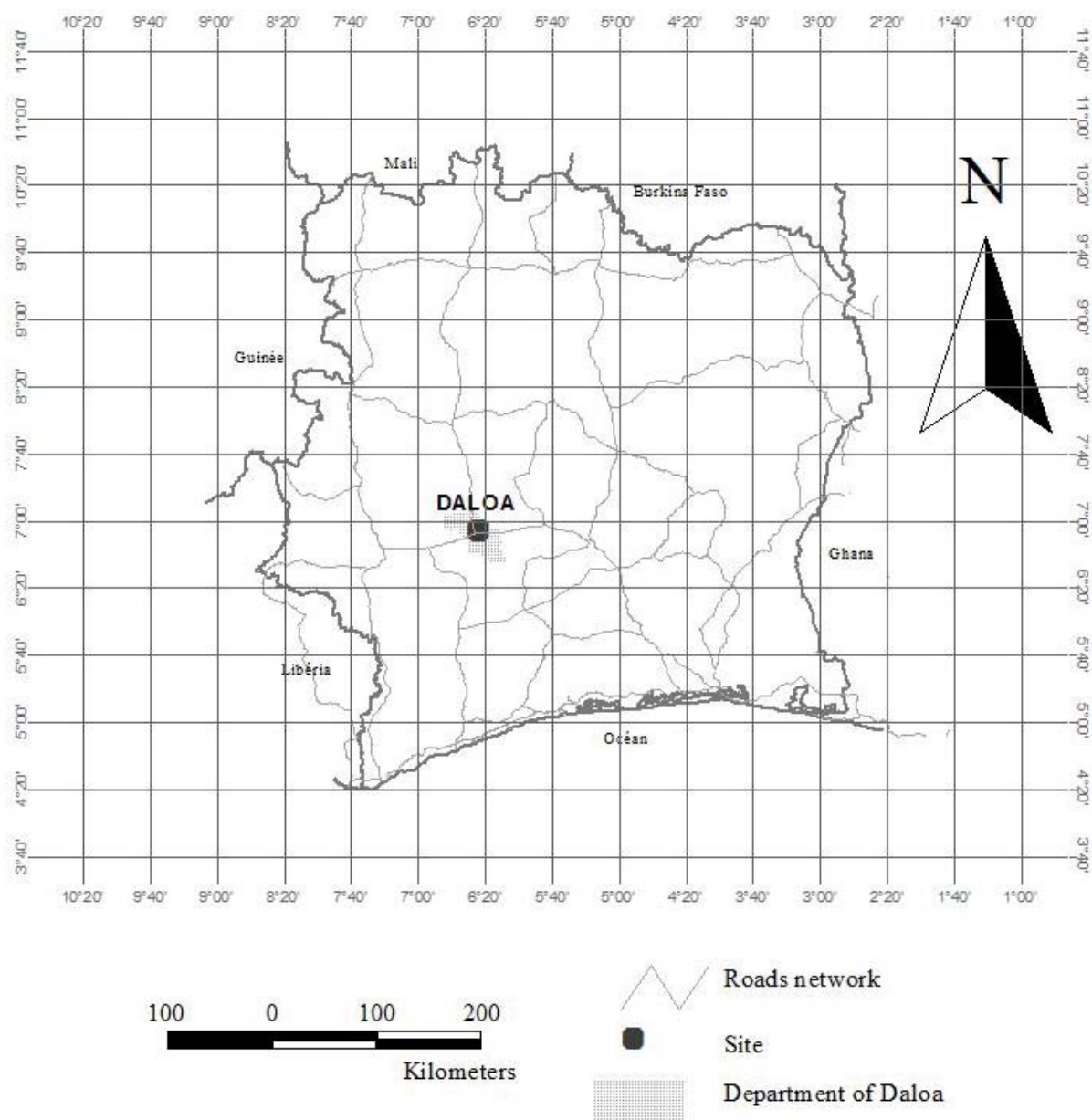


Fig. 1 Site location.

physically described and cow manure applied at 5 t/ha.

2.4 Observations and Data Analysis

Once a seed sprouts on the plot, weekly observations are made to count the number of germs up to the maximum germination. The values obtained were cumulated weekly. Finally, the total blooming germs and sprouting rates were calculated. Data analysis was done with SAS 8.2 version and all curves

were drawn using Origin 5.0 version.

3. Results

Soil study has been based on physical aspects taking in account the deep, the texture and the structure. The thin texture associated with good organic matter level in the top horizons permitted concluding in a good cation exchange capacity (CEC) and a good nutrition disposition for plants. The intense biological activity demonstrates a good pH level. Soil's



Fig. 2 Seed origin on a *Kponan* full season mother seed tuber.

deep complete its aptitude for yam cultivation.

3.1 Sprouting Faculty of *Kponan* Full Season Tubers

Kponan seeds from the three portions of full season tuber sprouted with different sprouting dates. The sprouting curves have the same evolution for the three origins (Fig. 3) but reached different final rates.

The top portion seeds sprouted between the 10th and 14th day after planting (dap) as well as seeds of the control (*Krengle*). Germination period lasted 77 days when total half sprouting rate is reached at the 36th dap comparable to *Krengle* 34th dap. These two types of seeds have similar developments with maximum sprouting rates of 90.3% (top) and 94.4% for *Kponan* top portion and *Krengle* seed, respectively.

The medium and distal portions seeds initiated germination at 28 dap and 35 dap, respectively, i.e., two and three weeks after top portion seeds. They reached half sprouting around the 52nd dap for medium portion seeds and the 60th dap for the tail portion seeds. Their sprouting took time to initiate but did not last long. In fact, half of the total sprout seed

sprouted in two and three weeks, respectively, for tail and medium portions.

Two and three weeks separate germination initiation of seeds from top segment of that respectively of the medium and tail portions. These values are supported by the linear evolution of simulated germination (Fig. 4). Indeed, the slopes of the regression lines are significantly close two by two according to the evolution of germination.

3.2 Analysis of Tuber Global Germination Power

Considering *Krengle* mother seed and *Kponan* single harvested tubers, germination initiation delay is about two weeks (10-14 dap). Half rate of germination is reached for *Krengle* the 33rd dap while it is reached for *Kponan* at the 43rd dap. Seventy eight point one percent of the seed from the whole *Kponan* tuber have sprouted at the end of 77 dap while 94.4% of *Krengle* sprouted.

Statistical analysis showed a significant difference for seeds sprouting depending on variety. In fact, the difference is weakly significant between *Krengle* and *Kponan* full season harvested tubers used as seed (prob.

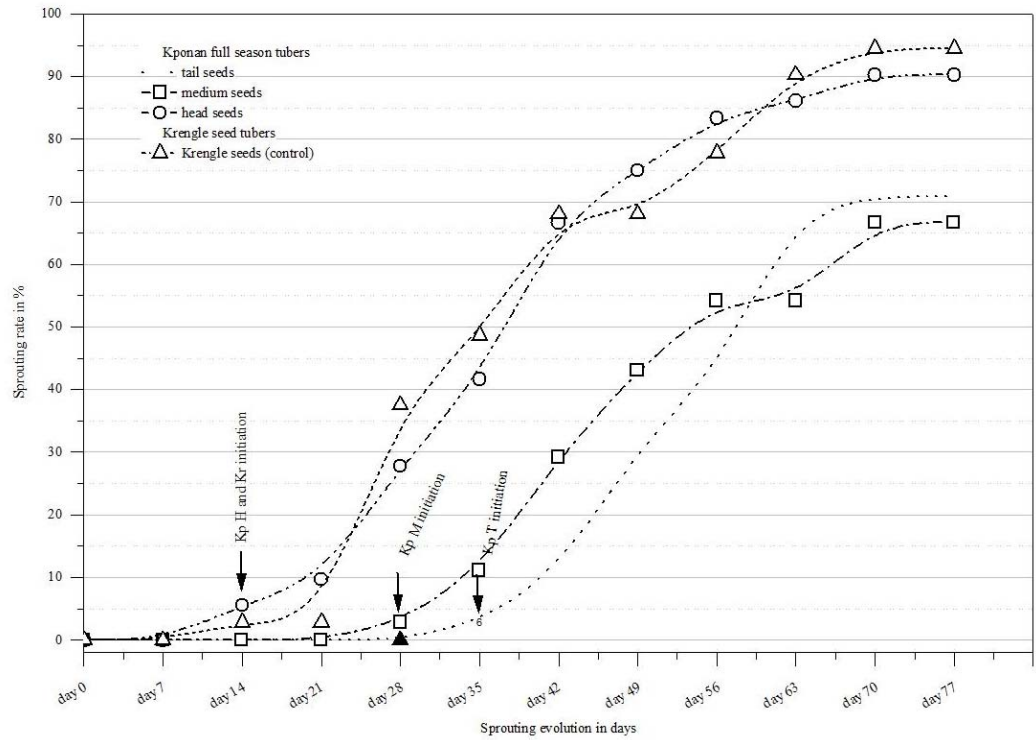


Fig. 3 Real sprouting curves of *Kponan* and *Krengle* according to the seed origin on the *Kponan* tuber. Kp H: head seeds; Kp M: *Kponan* medium seeds; Kp T: *Kponan* tail seeds.

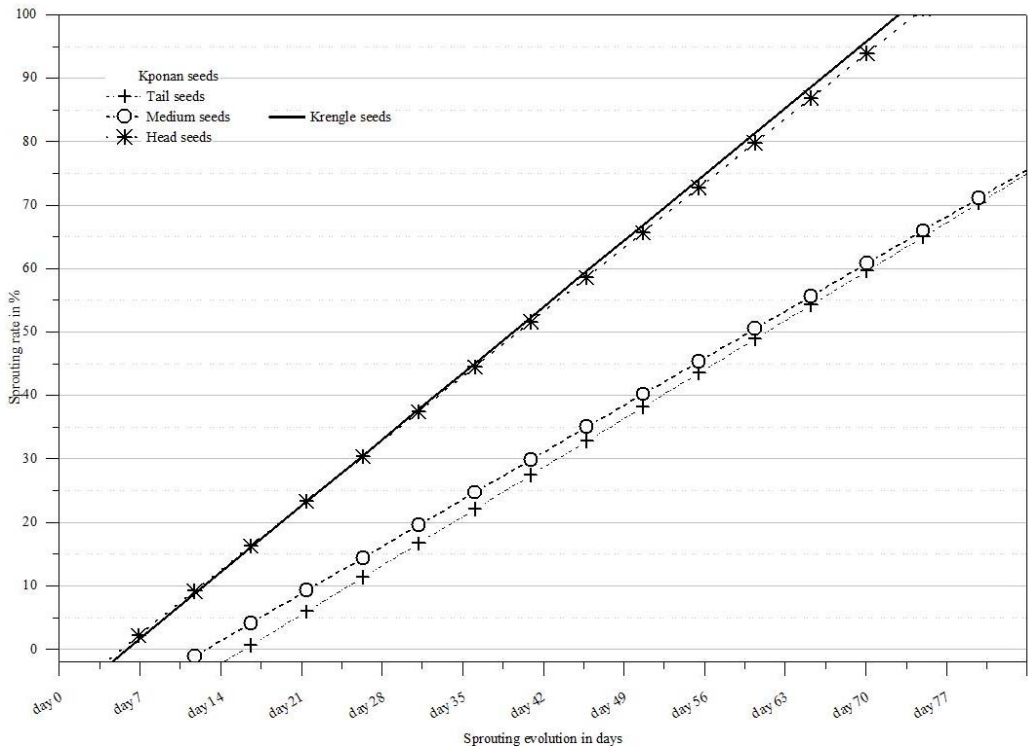


Fig. 4 Simulated linear sprouting curves of *Kponan* and *Krengle* according to the seed origin on the *Kponan* tuber.

$P = 0.031$ with $\alpha = 0.05$ and $r^2 = 64.62$, $lsd = 3.62$) (Fig. 5). P is P -value, α is the level of significance, r^2 is the coefficient of determination and lsd is the least significative difference.

Similarly, germination is expressed differently for seed from different portions of *Kponan* full season tuber. We observed a sprouting gradient head-tail or top-down oriented while the distal portion seeds offer more sprouted plants than the median portion ones at the end of the 77 days period.

3.3 Germination Gradient

We also observed two weeks time period for sprouting initiation between *Kponan* tuber's top portion and *Kponan* median seeds and one week time separates tail seeds sprouting initiation from median ones. In addition, the margin between germination rate of different origin of seed (Fig. 6) is very weakly significant (0.0503 with $\alpha = 0.05$). Although that difference, sprouting curves had the same evolution style. *Kponan* top seeds and *Krengle* ones had the same evolution while *Kponan* medium and tail seeds sprouted the same way. A head-tail oriented gradient is defined for *Kponan* full season harvest tubers. Although the germination rates of the fragments are interesting, they do not allow us concluding with

confidence concerning agronomic value of the *Kponan* full season tubers. Taking into account the yield at harvest can adjust this conclusion. Despite differential germination, seeds from proximal portion of *Kponan* tubers can be used as seed for yam production. It is then useful to test *Kponan* small tubers as seed in *Kponan* production as done in late yam production since proximal portion of the seed tubers perform as *Krengle* seed tubers: Their sprouting faculties are nearly equal. At the end of 11 weeks or about 77 days, the average rate of 98% achieved with proximal seed satisfactory to enable on farm production.

3.4 Tuber Yield

The cycle lasted eight months from May to December. Harvest has been made and results in Table 1 had been obtained. Yields varied from 20.6 t/ha (*Krengle*) to 34.2 t/ha (*Kponan* medium seed). If those yield levels seem to be high for *Krengle*, they can be acceptable for *Kponan* that has been yielded once in opposition to its habitual uses (two harvests). The medium fragments gave the best yield not significantly different from proximal seeds yield. However, full season *Kponan* tuber had best yield compared to the control *Krengle* (Table 2).

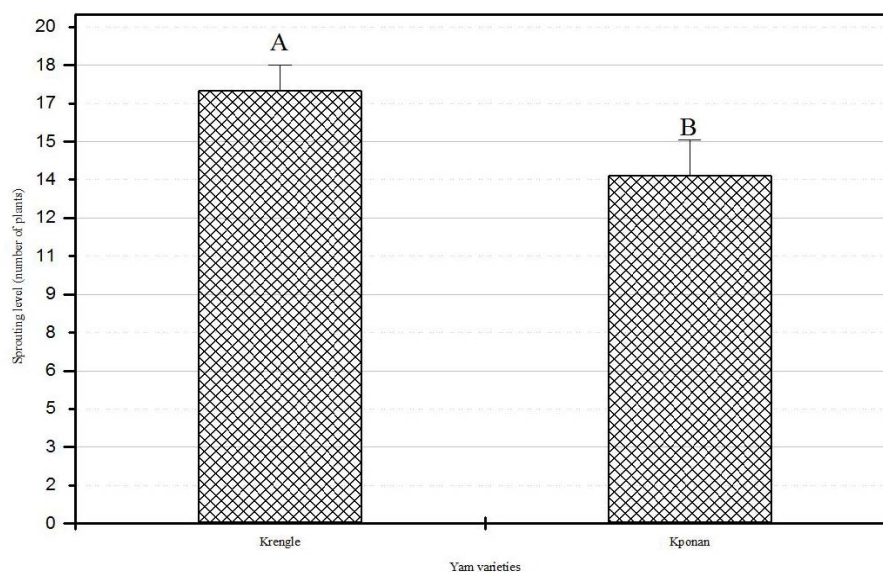


Fig. 5 Mean of sprouts according to the variety.
Means with the same letters are not significantly different.

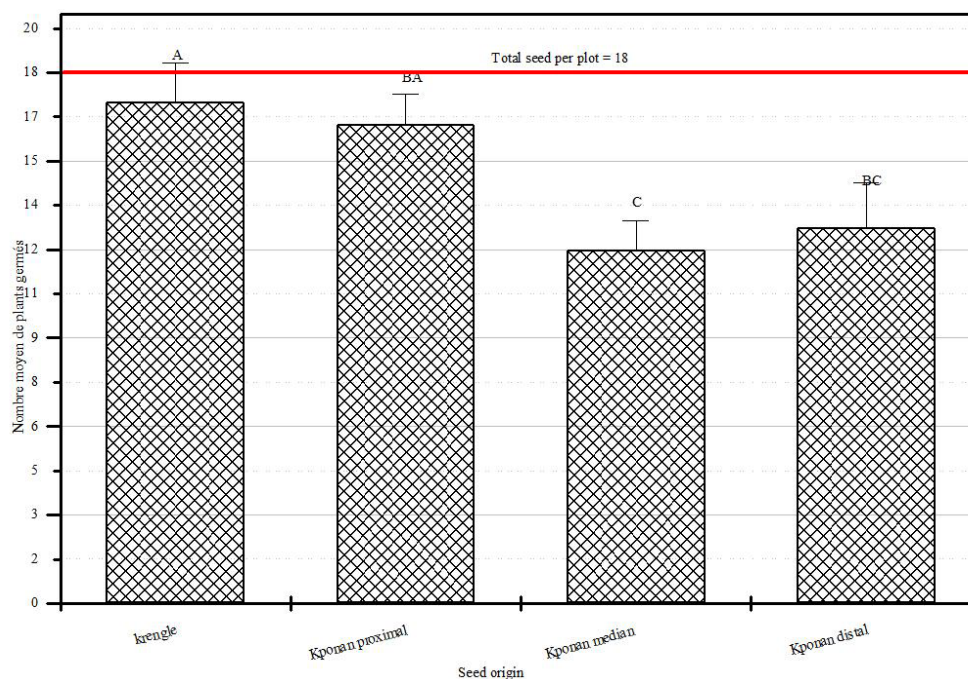


Fig. 6 Total sprouted seeds per variety according to seed origin on the tuber.

Means with the same letters are not significantly different.

Table 1 Tuber yield from different fragments of *Kponan* yam.

Mean	Repetitions	Seed type
34.25 ^a	4	<i>Kponan</i> medium
28.87 ^{ba}	4	<i>Kponan</i> proximal
26.48 ^{ba}	4	<i>Kponan</i> distal
20.67 ^b	4	<i>Krenge</i>

$R^2 = 0.58$; $\alpha = 0.05$; means with the same letters are not significantly different.

Table 2 *Kponan* yield compared to *Krenge*.

Mean	Repetitions	Variety
29.865 ^a	12	<i>Kponan</i>
20.673 ^b	4	<i>Krenge</i>

Means with the same letters are not significantly different.

Table 3 Multiplication factors.

Mean	N	Seed type
9.988 ^a	4	<i>Kponan</i> median
8.166 ^{ba}	4	<i>Kponan</i> proximal
7.985 ^{ba}	4	<i>Kponan</i> distal
5.796 ^b	4	<i>Krenge</i>

Means with the same letters are not significantly different.

3.5 Multiplication Rate

In yam production, multiplication rate limited the crop propagation. The experience led to multiplication rates higher (Table 3) for medium fragment of *Kponan*

full season tuber (9.9) than control *Krenge* (5.8). However, full season *Kponan* seeds had multiplication rate high than *Krenge*.

4. Discussion

This study reveals the ability of the full season tuber of *Kponan* yam to sprout in conformity with Adu-Gyamfi and Blay [11] who concluded test on milked and full season grown *Pona* and *Labreko* tubers response to mini sett technique. It confirms the precocity of sprouting for seed from top portion compared to the other portions of the tuber in *Dioscorea cayenensis-rotundata* [12]. On the other hand, we noticed a sprouting according to a top-to-tail gradient as described by Dumont and Tokpa [13]. This gradient is different for *D. alata* varieties that is tail-to-top oriented as described by Kpemoua and N'kpenu [14].

Differential sprouting of the portions may be related to specific factors of the tuber as its physiological age and especially its sanitary status. In fact, according to Onwueme and Haverkort [15], the specie and/or variety, the mother tuber, the seed origin on the

mother tuber, seed physiological age and its health status influence germination. The seeds are certainly not the same age and have different origins.

Accordingly, the dormancy is longer for yam tubers from regions with long dry periods than tubers from areas with short dry seasons. Natural dormancy varies between four and 18 weeks.

Sprouting progression in *Kponan* full season harvest tuber seed varies between 19% and 40% at the 40th dap is similar to that described by Kpemoua and N'kpenu [14] for *Dioscorea cayenensis-rotundata* (5%-43%). The final sprouting rate of 78.1% at the 77th dap is comparable to that of 76% obtained by Badohoun [16] after 75 days in *Dioscorea cayenensis*. The sprouting lasted 77 days after planting. This level is satisfactory and could be improved in a seed production system.

Considering the fact that the tuber initiation takes place 2-3 months after germination, we can expect tuber initiation 3.5-4.5 months after planting. Early harvest occurring 5-6 months after planting offers immature tubers that made them difficult to conserve and also justified that they sprout.

In rainy conditions and sufficient sunshine, between the 9th and the 10th month harvesting may provide a good yield according to the sprouting rate.

Germination rate is different as far as *Kponan* and *Krengle* are considered even if both had the same sprouting progression in conformity with Tiem [17] who consider an evolution depending on variety. In effect, N'kpenu et al. [18] and Kouakou et al. [19] also confirmed that the sprouting depended on the variety.

The global sprouting rate (> 78%) of *Kponan* full season tubers used as seed is satisfactory and can allow us developing its uses in yam production. With such a rate, we can expect a harvest density not significantly different. Indeed, yield is positively correlated to harvest density [2]. In the practical aspect, the first two and three top of the tuber giving the best results may be preferred to the use of the tail

portions. However, we can recommend using small tubers of about 200 g to 500 g as full season seed mothers for *Kponan* production. The behavior of the remaining 2/3 composed of medium and tail seeds must be taken in account once we make harvest and see yield evolution. In fact, yield being one of the principal components guiding farmers' decision [6], harvest data give more precisions on the agronomic use of that *Kponan* full season tuber. It should be noticed that despite this differential sprouting, all plants of the plot will initiate the tuber at the same period according to sunlight and sun irradiation variation. Indeed, plants of different planting dates seem to initiate the tuber at the same period.

High yield level has been reached in relation with the cycle duration. In fact, according to Houedjissin and Koudande [20], later is planting between July and November, shorter is the vegetative phase and smaller are the tubers yields. These yield levels should be considered with the production conditions. The area is in a forest zone with long fallow period (more than 12 years); soil fertility had been regenerated. The full season harvest for *Kponan* can also justify those yields levels. In fact, *Kponan* is normally harvested twice a cycle for consumption and seed. The cumulated yield (first and second) sometimes approaches 15 t/ha [21] with a break in the first tuber's growth and a new tuber initiation. The full season tuber cumulates more reserves and gets more mature. In the traditional practice, first harvest tubers are immature that justify they do not germinate and are difficult to conserve.

5. Conclusions

By studying sprouting ability of full season tubers of *Kponan* yam, we plan to improve that famous yam variety production both in rainy and dry seasons. The sprouting rates are agronomically acceptable for field production. Yields are so interesting that it will be very useful to confirm them and look for strategies to transfer those results to farmer. This work can help us

improve *Kponan* yam availability and food security if we reach the transfer level.

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