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Comparative Study of Dormant Bud Development in Taro [*Xanthosoma sagittifolium*, *Xanthosoma* sp. and *Colocasia esculenta* (L.) Schott] in Relation to their Size and Localization on the Principal Tuber

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The study was to determine the effects of variety, position and bud size on six parameters of taro development and production. For that, 480 tuber cuttings of three varieties (C1, C3, CD) of *Colocasia* and (X1, X4, X5) of *Xanthosoma* carrying small and large buds were sown in a complete randomized blocks design with two repetitions, in the University Félix Houphouët-Boigny (Côte d'Ivoire). The analyses showed that leaves of X5 emerged earlier (23 days). Also, leaves limb of X1, X4, X5 are longer (22 to 25 cm) and wider (20 to 25 cm) than those of C3 and CD (19 cm). Petioles and leaves are longer (51 and 74.25 cm, respectively) in X1. In contrast, *Colocasia* produced more tubers. Overall, bud of the top germinated earlier (26 days), generated longer (22.90 cm) and wider (22.54 cm) laminas and more tubers. Conversely, petioles and leaves from bud of the middle are longer. Also the large buds sprouted earlier (24.82 days) and generated longer (24.09 cm), wider (23.48 cm) laminas, longer petioles (45.32 cm) and leaves (69.43 cm). Furthermore, in individual varieties, on the one hand, plants grown from top buds presented the widest laminas (19.89 and 25.58 cm), in CD and X5, the longest petioles and leaves (41.44 and 67.83 cm) and, in addition, produced the greatest number (3.35) of tubers, in X5. On the other hand, large bud germinated earlier (25.20 days) in C3 and generated the longest laminas (19.71 to 26.84 cm) in the five varieties, wide (21.96 to 27.32 cm) in X1, X4, C3, the longest petioles (46.57 cm) in C3, longest leaves (61.30 to 79.73 cm) in C3, X1, X4 and the greatest number (3 to 6.23) of tubers in C3 and X4. All these findings should be exploited for better taro production.

Keywords: Taro (Colocasia esculenta, Xanthosoma sagittifolium); bud size and localization; plant development; production.

1. INTRODUCTION

Cultivated in tropical and sub-tropical humid regions (Chaïr et al. [1]), taro, in Côte d'Ivoire, is dedicated to the edible varieties of *Colocasia esculenta* and genus *Xanthosoma* (*Xanthosoma sagittifolium* and *Xanthosoma* sp) (Sangaré et al. [2]; Anon et al. [3]; Koffi et al. [4]; Koffi and Koffi [5]), even though taro countrywide diversity remains uncertainty (Gnangbé and Kouacou [6]; Koffi and Koffi [5]).

Taro is cultivated for all its parts (Boakye et al. [7]) important in several utilizations. Corms and tubers play a very important role in food security: they are staple foods in certain regions (Akwee et al. [8]; Koffi et al. [4]; Ashish and Sing [9]). These corms are an important source of energy due to their high richness in starch than cassava and yam (Amani [10]; Bosson [11]; Amon et al. [12]; Akwee et al. [8] ; Romero et al. [13] ; Ashish and Singh [9]).

Corms and leaves have considerable nutritional and health benefits broader compared to other root and tuber crops (Amon et al. [12]; Akwee et al. [8]; Ubalua et al. [14]: Habtamu and Tesfahun [15]; Ashish and Singh [9]). Corms can also be used for industrial purposes (Owusu-Darko et al. [16]; Anon et al. [3]; Ashish and Singh [9]).

In addition, taro is of economic (Akwee et al. [8]) and socio-cultural (Ubalua et al. [14]) importance. Taro corms and leaves have medical, pharmacological and therapeutic uses (Akwee et al. [8]; Ashish and Singh [9]).

Though introduced in Africa, this continent is the leading producer, with 77.67 % of world production, in 2020 (FAOSTAT [17]). However, in spite of its advantages, taro is a neglected and underexploited food crop, so that its production decreases or is very low in some countries such as Côte d'Ivoire. Indeed, in this country, taro cultivation remains limited to the southern humid part of its surface (Koffi and Koffi [5]). Thus taro is, until 2020, the third root and tuber crop after yam and cassava, with a production 73 to 86 times lower (FAOSTAT [17]). Several factors underlie this situation, including rainfall irregularity (or shortage of rainy seasons), soil infertility and inefficient marketing, the most common (Bammite et al. [18]). In Côte d'Ivoire, in particular, taro is consumed in period in which the principal products lack.

Moreover, worldwide, taro is, traditionally, reproduced vegetatively in different manners depending on the variety by rhizome, entire tuber, corm, cormel, sucker cuttings. Any cutting carries in all levels one or more dormant buds of different sizes. Buds localized in the top part are more inhibited by the apical meristem than those localized in the middle and bottom parts of the tuber (Cline [19]; Carles and Fletcher [20]; Dun et al. [21]; Lazare and Zaccai [22]; Zhihui et al. [23]). Hence, in vegetative propagation, size and location of buds on cuttings influence development, growth and production (Megersa [24]). In taro, no information exists on the nature and the aquity of these influences, in cultivation on soil, neither at the specific level, nor at the varietal level.

Then, on the basis of the above-mentioned postulates, the germination of dormant buds, the growth and development and the production of plants differ according to the size and position of the buds.

Thus the current investigation was to determine the effects of variety, position and bud size on the developmental and production traits of taro varieties of *Colocasia esculentus* and *Xanthosoma sagittifolium*.

2. MATERIALS AND METHODS

2.1 Plant Material

Five hundred and sixty tuber cuttings of six local taro varieties, the most consumed and economically interesting in Côte d’Ivoire. These varieties, as identified by Gnangbé and Kouacou [6], are coded C1, C3, CD (a complex of varieties C5 and C6) for *Colocasia esculenta* and X1, X4, X5 for *Xanthossoma sagittifolium* and *Xanthosoma* sp. The tubers were harvested on one-year old plants.

The tubers of C1, CD, X4 and X5 are relatively short; two axillary bud localizations were distinguished: the top (T) and the base (B). For those of C3 and X1 relatively long, three localizations were distinguished: the top (T), the middle (M) and the base (B).

For any localization, two types of buds were considered: large bud (L) (0.5 to 2 cm in diameter) and small bud (S). Any cutting carries only one dormant, large or small, bud. Ten cuttings with large bud and ten others with small bud were used per localization and variety. For each one of the varieties C1, CD, X4 and X5, 40 cuttings were obtained, while 60 were obtained for C3 and X1.

2.2 Experimental Site

The field experiment was carried out at the experimental park in Centre National de Floristique (between 3°57 and 3°59 north latitude and between 5°18 and 5°20 west longitude) (N'Goran et al. [25]) of the University Félix Houphouët-Boigny, Abidjan, Côte d’Ivoire.

This center is under a tropical type climate with two dry seasons and two rainy seasons. From 2003 to 2022, the average annual precipitation was around 2,000 mm and the average monthly temperature was 22.5 to 35 s°C (SODEXAM [26]). The soil is ferrasol type, sandy and ferralitic, highly desaturated (Perraud [27]). The forest massif belongs to the ombrophile sector of the Guinean domain where the vegetation is dominated by dense evergreen humid forest (Kouamé and Zoro [28]).

2.3 Experimental Design and Trial Monitoring

The experiment was laid out in a complete randomized block design with two replications. Each block, composed of 10 rows spaced of 0.75 cm, encompassed 280 cuttings representing the six varieties studied. In a given row, 28 cuttings for the six varieties were randomly planted: each of the varieties C1, CD, X4, X5 was represented by four cuttings. These are cutting from the top carrying large bud, cutting from the top carrying small bud, cutting from the base carrying large bud, cutting from the base carrying small bud. While C3 and X1 were represented respectively by six ones: these are cuttings describes above and cutting from the middle carrying large bud and cutting from the middle carrying small bud.

The cuttings were planted one per hole 10 to 15 cm deep, with the bud under. In cases of lack of rain, daily irrigation was conducted.

2.4 Data Collection

The following parameters were observed and measured: days to emergence (DE) of plantlet or first leaf, lamina length (LL), lamina width (LW), petiole length (PL), total leaf length (TLL), and the number of tubers per plant (NTP) eight months after planting. Foliar morphology parameters (LL, LW, PL, TLL) were measured on the most developed leaf 45 days after each plant emergence. In taro, these parameters express plant vigour.

2.5 Data Processing

Normal distribution of the data collected was forehand checked, then Student t test, one and two ways analysis of variance (ANOVA) were performed to test the effect of bud localization and bud size on the parameters considered, separately within each variety and globally with all the varieties. Effects of species and variety were also tested. In case of significant effect, the least significant difference (LSD) of Fisher test was realized to establish groups of localizations and varieties. The analyses were performed on Statistica 7.1.

3. RESULTS

3.1 Observations

Cuttings of variety C1 did not germinate. Also, eight months after planting, only three plants of the complex of varieties CD flowered, representing 16.67 % of the varieties. 3.75 % of CD plants and 0.63 % of all tested plants.

3.2 Effect of the Species on the Parameters Studied

Mean values differed very highly significantly (*P* = .000) (Table 1) between *Colocasia* and *Xanthosoma* for lamina length (LL), lamina width (LW) and number of tubers per plant (NTP), except (*P* > .05) for the days to emergence (DE), petiole length (PL) and total leaf length (TLL). *Xanthosoma* leaf blades are longer and wider. In contrast, *Colocasia* produced more tubers (Table 1).

3.3 Global Effect of the Variety on the Parameters Studied

Significant (*P* = .02) and very highly significant (*P* = .00) differences were observed among the five varieties for the six parameters studied (Table 2). Leaves emerged earlier (23 days in average after sowing) in X5 and later (31 days) in C3. These emerged in the same delay (about 29 days) in X1 and X4 (Table 2). Lamina length (LL) of *Colocasia* varieties, C3 and CD, are inferior (about 19 cm) to those of *Xanthosoma* varieties (X1, X4, X5) (22 to 25 cm) (Table 2). Likewise, lamina width (LW) of *Colocasia* varieties, C3 and CD, are inferior (about 19 cm) to those of *Xanthosoma* varieties (X1, X4, X5) (20 cm in X4 to 25 cm in X1) (Table 2). Petiole are more long (51 cm) in X1 and less long (34 to 37 cm, in average) in the two varieties (X4, X5) of *Xanthosoma*. In *Colocasia* varieties, petioles are more long in CD. Total leaf length varies consequently identically to petiole length (Table 2). *Colocasia* varieties (C3, CD) produced more tubers (5 to 6) than *Xanthosoma* ones (2 to 3, in average).

Table 1. Effects of species on the parameters studied

Species	**Parameters**					
	DE (days)	**LL (cm)**	**LW (cm)**	**PL (cm)**	**TLL (cm)**	**NTP**
Colocasia	29.08540^{a}	18.82060^{b}	19.09180^{b}	44.86420^{a}	63.85080^{a}	5.20400^{a}
Xanthosoma	27.16786^{a}	23.81143^{a}	23.14143^{a}	42.28357^{a}	65.67357^{a}	2.32486^{b}
P	.26	.000	.000	.10	.37	.000

DE: Days to emergence of plantlet or first leaf; LL: lamina length; LW: lamina width; PL: petiole length; TLL: total leaf length; NTP: number of tubers per plant eight months after sowing. .

Foliar morphology parameters (LL, LW, PL, TLL) were measured on the most developed leaf forty-five days after planting

Table 2. Effects of the variety on the parameters studied

Varieties	**Parameters**					
	DE (days)	**LL (cm)**	**LW (cm)**	**PL (cm)**	**TLL (cm)**	**NTP**
C3	30.54167^{a}	19.10933^{b}	19.42633^{c}	43.31333^{b}	62.42300^{bc}	5.438333^{a}
CD	26.90100^{ab}	18.38750^{b}	18.59000^{c}	47.19050^{ab}	65.99250^{b}	4.852500^{a}
X1	29.55000^{a}	24.70500^{a}	25.07500^{a}	51.09800^{a}	74.25000^{a}	1.894667^{b}
X4	28.51250^{a}	22.40250^{a}	20.35500^{bc}	34.1b7000^{c}	56.56750^{c}	2.720000^{b}
X5	22.25000^{b}	24.15500^{a}	23.02750^{ab}	37.17550^{c}	61.91500^{bc}	2.575000^{b}
P	.02	.000	.000	.000	.000	.000

DE: Days to emergence of plantlet or first leaf; LL: lamina length; LW: lamina width; PL: petiole length; TLL: total leaf length; NTP: number of tubers per plant eight months after sowing

Foliar morphology parameters (LL, LW, PL, TLL) were measured on the most developed leaf forty-five days after planting

Table 3. Global effects of bud localization on the parameters studied

Localization	Parameters					
	DE (days)	**LL** (cm)	**LW** (cm)	**PL** (cm)	**TLL** (cm)	**NTP**
Top	25.8152^{b}	22.9070^{a}	22.5468^{a}	44.3864^{b}	66.6930^{a}	4.00300^{a}
Middle	33.1500^{a}	21.2425^{ab}	22.2050^{ab}	47.7295^{a}	68.9600^{a}	3.16700^{b}
Base	28.0452^{ab}	20.7526^{b}	20.0610^{b}	40.5830^{c}	61.5168^{b}	3.18900^{b}
P	.010551	.005847	.001079	.001693	.006301	.010725

DE: Days to emergence of plantlet or first leaf; LL: lamina length; LW: lamina width; PL: petiole length; TLL: total leaf length; NTP: number of tubers per plant eight months after sowing

Foliar morphology parameters (LL, LW, PL, TLL) were measured on the most developed leaf forty-five days after planting.

Table 4. Global effects of bud size on the parameters studied

Bud size	Parameters					
	DE (days)	**LL (cm)**	**LW (cm)**	**PL (cm)**	**TLL (cm)**	**NTP**
Small	31.11700^{a}	19.37467^{b}	19.42333^{b}	41.39950^{b}	60.40150^{b}	3.24833^{a}
Large	24.81667^{b}	24.08917^{a}	23.48483^{a}	45.31817^{a}	69.42667^{a}	3.80067^{a}
P	.000	.000	.000	.012	.000	.16

DE: Days to emergence of plantlet or first leaf; LL: lamina length; LW: lamina width; PL: petiole length; TLL: total leaf length; NTP: number of tubers per plant eight months after sowing. .

Foliar morphology parameters (LL, LW, PL, TLL) were measured on the most developed leaf forty-five days after planting

Table 5. **Effect of bud localization on the parameters in each variety**

Treatment		Parameters					
		DE (days)	**LL** (cm)	**LW** (cm)	**PL** (cm)	**TLL** (cm**)**	**NTP**
C3	T	26.97000^{a}	20.30000^{a}	20.28900^{a}	44.84500^{a}	65.16500^{a}	6.415000^{a}
	M	31.30000^{a}	18.64000^{a}	19.29000^{a}	43.88000^{a}	62.52000^{a}	4.600000^{a}
	B	33.35500^{a}	18.38800^{a}	18.70000^{a}	41.21500^{a}	59.58400^{a}	5.300000^{a}
	P	.18	.52	.66	.47	.48	.18
CD	T	25.75600^{a}	19.47000^{a}	19.89000^{a}	48.34200^{a}	67.78000^{a}	5.40000^{a}
	B	28.04600^{a}	17.30500^{a}	17.29000^{b}	46.03900^{a}	64.20500^{a}	4.30500^{a}
	P	.43	.10	.03	.33	.30	.25
X1	T	27.75000^{a}	25.15000^{a}	26.38000^{a}	53.74000^{a}	75.90000^{a}	1.900000^{a}
	M	35.00000^{a}	23.84500^{a}	25.12000^{a}	51.57900^{a}	75.40000^{a}	1.734000^{a}
	B	25.90000^{a}	23.47000^{a}	23.72500^{a}	47.97500^{a}	71.45000^{a}	2.050000^{a}
	P	.31	.56	.30	.16	.54	.72
X4	T	27.15000^{a}	23.23500^{a}	20.59500^{a}	33.56500^{a}	56.79000^{a}	2.95000^{a}
	B	29.87500^{a}	21.57000^{a}	20.11500^{a}	34.77500^{a}	56.34500^{a}	2.49000^{a}
	P	.43	.38	.76	.61	.92	.28
X5	T	21.45000^{a}	26.38000^{a}	25.58000^{a}	41.44000^{a}	67.83000^{a}	3.35000^{a}
	B	23.05000^{a}	23.03000^{a}	20.47500^{b}	32.91100^{b}	56.00000^{b}	1.80000^{b}
	P	.06	.09	.015	.000	.003	.008

DE: Days to emergence of plantlet or first leaf; LL: lamina length; LW: lamina width; PL: petiole length; TLL: total leaf length; NTP: number of tubers per plant eight months after sowing. T: bud of the top of the tuber, M: bud of the middle of the tuber, B: bud of the base of the tuber.

Foliar morphology parameters (LL, LW, PL, TLL) were measured on the most developed leaf forty-five days after planting

3.4 Global Effect of Bud Localization on the Parameters

Significant (*P* < .05) to highly significant (*P* < .01) differences were observed in the mean values of the six parameters among the three localizations considered (Table 3). Bud of the top (T) germinated earlier (26 days), while those of the middle (M) later (34 days). Laminas derived from bud of the top (T) are slightly longer (22.90 cm)

Table 6. **Effects of bud size on the parameters in each variety**

Treatments		Parameters					
		DE (days)	**LL (cm)**	**LW (cm)**	**PL (cm)**	**TLL (cm)**	**NTP**
C3	S	35.88333^{a}	15.80867^{b}	16.49000^{b}	40.05333^{b}	55.77600^{b}	4.64333^{b}
	L	25.20000^{b}	22.41000^{a}	22.36267^{a}	46.57333^{a}	69.07000^{a}	6.23333^{a}
	P	.000	.000	.000	.005	.000	.04
CD	S	28.40200^{a}	17.07000^{b}	17.46000^{a}	45.67700^{a}	63.59500^{a}	5.30500^{a}
	L	25.40000^{a}	19.70500^{a}	19.72000^{a}	45.67700^{a}	68.39000^{a}	4.40000^{a}
	P	.30	.04	.07	.20	.16	.35
X1	S	34.23333^{a}	22.01667^{b}	22.83000^{b}	48.75667^{a}	68.76667^{b}	1.65333^{a}
	L	24.86667^{a}	26.29333^{a}	27.32000^{a}	53.43933^{a}	79.73333^{a}	2.13600^{a}
	P	,06	.000	.000	.059	.000	.12
X4	S	30.97500^{a}	19.87000^{b}	18.75500^{b}	31.97500^{a}	51.83500^{b}	2.29000^{b}
	L	26.05000^{a}	24.93500^{a}	21.95500^{a}	36.36500^{a}	61.30000^{a}	3.15000^{a}
	P	.14	.002	.03	.053	.02	.03
X5	S	22.15000^{a}	22.57000^{b}	21.34500^{a}	37.53000^{a}	60.16500^{a}	2.45000^{a}
	L	22.35000^{a}	26.84000^{a}	24.71000^{a}	36.82100^{a}	63.66500^{a}	2.70000^{a}
	P	.82	.03	.12	.80	.43	.69

DE: Days to emergence of plantlet or first leaf; LL: lamina length; LW: lamina width; PL: petiole length; TLL: total leaf length; NTP: number of tubers per plant eight months after sowing. .

Foliar morphology parameters (LL, LW, PL, TLL) were measured on the most developed leaf forty-five days after planting.

S: small bud; L: large bud.

and wider (22.54 cm), those derived from bud of the base (B) are less long (20.75 cm) and wide (20 cm) (Table 3). Petiole derived from bud of the middle (M) are more long (47.73 cm), while petiole derived from bud of the base (B) are slightly less long (40.58 cm) (Table 3). Consequently, total leaf length presented identical variations. Plants derived from bud of the top (T) produced, in average, one unit more of tubers (4) (Table 3).

3.5 Global Effect of Bud Size on the Parameters

Significant (*P* < .05), highly significant (*P* < .01) and very highly significant (*P* < .001) differences were observed (Table 4) in values between small and large buds for the parameters, except for number of tubers per plant (NTP) (*P* > .05). The large buds sprouted earlier and the resulting plants showed longer, wider leaf blades, longer petioles and leaves (Table 4).

3.6 In Each Variety

3.6.1 Effect of bud localization

Analysis of variance (ANOVA) and t test did not show any differences (*P* > .05), respectively, in varieties C3 and X1 and in X4 among bud localizations for the six parameters (Table 5). But, t test revealed significant (*P* < .05) differences only for LW in CD (Table 5). Also, in X5, significant (*P* < .05) differences for LW, highly significant (*P* < .01) for TLL and NTP and very highly significant (*P* = .000) differences for PL were observed (Table 5).

For LW in CD and X5, plants resulting from buds of the top showed the widest laminas. In X5, this same type of plants has the longest petioles and leaves; they also produced the highest number of tubers (Table 5).

3.6.2 Effect of bud size

In CD and X5, significant (*P* < .05) differences were observed only for lamina length (LL) between small (S) and large (L) buds (Table 6). Plants resulted from large buds presented the longest laminas. In X1, very highly significant (*P* < .001) differences were observed between small (S) and large (L) buds for LL, LW and TLL. Plants resulted from large bud presented the longest and widest laminas, with the longest leaves. In X4, significant (*P* < .05) differences for LW, TLL and NTP and highly significant (*P* < .01) differences for LL were observed between small (S) and large (L) buds. Plants resulted from large bud presented the longest and widest laminas, the longest leaves and produced the highest number of tubers. In C3, significant (*P* < .05) to very highly significant (*P* = .000000) differences between small (S) and large (L) buds were observed for the six parameters. Large buds germinated earlier; plants derived from them have the longest and widest laminas, the longest petioles and leaves, and have produced the highest number of tubers (Table 6).

4. DISCUSSION

The localization and the size of the buds present on the cuttings influence development, growth and production (Megersa [24]). These influences were assessed for their senses and levels in five varieties of taro (*Colocasia esculenta*, *Xanthosoma sagittifolium* and *Xanthosoma* sp.), a crop mainly cultivated from tuber cuttings. The results of this evaluation have several aspects. Thus it was found that the cuttings of the *Colocasia esculenta* variety C1 sown have not germinate. Their relatively small size could be the cause. In fact, this variety is so susceptible to tuber rot that, traditionally, planting is established with plants obtained from germination of lateral small buds not harvested. Similar facts were observed by Osundare and Ayodele [29] in *Xanthosoma mafafa* in which percentage emergence of split corm (60 g) were lower than that of corm (200 g) and cormels (120 g). According to Bazel [30], this was caused as a result of “cut open edges of the split corm’’ which invited pythium soft rot and thus, led to the rotten of some of the split corm.

Concerning flowering, it was observed that only three plants of the *Colocasia* variety CD flowered, representing 16.67 % of the varieties. 3.75 % of C1 plants and 0.63 % of all plants monitored. This result confirms the scarcity flowering of taro. In addition, *Colocasia* varieties would flower more than those of *Xanthosoma*.

Significant to very highly significant differences both overall at the levels of the sources of variation species, variety, localization and size of the bud and singular at the levels of the localization and the size of the bud in each of the varieties were observed for the parameters analyzed.

In terms of overall differences, it was found that *Xanthosoma* leaf blades are longer and wider. In contrast, *Colocasia* produced more tubers. Similar observations have also been made by other authors. Thus, Bammite et al. [31] observed that plant height is slightly higher in *Xanthosoma mafaffa*. Touckia et al. [32] reported good vegetative growth in *Xanthosoma* varieties expressed in particular by higher lamina length and width, while in *Colocasia*, production was better with two to three times more tubers. This great aptitude for the production of *Colocasia* was mentioned by Okoli et al. [33] who reported the best performance of *Colocasia* cultivars in yield attributes, namely number of corms.

Regarding varieties, differences among them occurred for each of the parameters. No variety presented neither the highest nor the lowest values for all the parameters at the same time. Thus leaves emerged earlier (23 days in average after sowing) in X5 and later (31 days) in C3. These emerged in the same delay (about 29 days) in X1 and X4. But, laminas of *Colocasia* varieties, C3 and CD, are less long and wide (about 19 cm) than those of *Xanthosoma* varieties (X1, X4, X5), respectively, 22 to 25 cm and 20 cm in X4 to 25 cm in X1. Also, at petiole length and total leaf length, another type of stepwise variation was observed. Indeed, first the variety X1 presented the highest values, respectively, 51 and 74.25 cm, then the varieties (C3, CD) of *Colocasia* 43 to 47 cm and 26 to 66 cm, finally the two other varieties (X4, X5) of *Xanthosoma*, with 34 to 37 cm and 56 to 62 cm. However, the variety X1 whose buds germinated less early has presented the highest average values for lamina length, lamina width, petiole length, total leaf length. On the other hand, *Colocasia* varieties (C3, CD) produced more tubers (5 to 6) than *Xanthosoma* ones (2 to 3, on average). Similar differences were also highlighted for growth and its attributes plant height, diameter of pseudo-stem, petiole length, lamina length, lamina width, leaf area and yield attributes, number of corms, cormels and suckers per plant, cormel weight and yield per plant among *Colocasia esculenta*, *Xanthosoma sagittifolium* and *Xanthosoma mafaffa* genotypes, cultivars or accessions (ReyesCastro et al. [34]; Mengistu [35]; Bammite et al. [31]; Nwofia et al. [36]; Okoli et al. [33]).

Contrary to the pre-mentioned authors, Elijah et al. [37] found no differences among six accessions of *Colocasia* and *Xanthosoma* spp. in Nigeria for crop height, crop span, number of leaves, leaf length and width.

The differences between varieties also appeared in i*n-vitro* culture as evidenced by the results of Droh [38] in *Colocasia esculenta* where the growth rate, the number of roots, the number of leaves, the height of the plant, the number, the length and mass of the microtubers varied depending on the variety. The values of these parameters are higher in the C1 variety than in the other two, C4 and C6.

Mean values of the six parameters varied significantly among the three bud localizations. No localization generated neither the highest nor the lowest values for all six parameters at once. Thus, bud of the top germinated earlier (26 days), while those of the middle later (34 days). Interactions between plant hormones (auxin, cytokinins, gibberellins) and expression of plant genes associated with hormone turnover in tubers following splitting affect bud germination (Hartmann et al. [39]; Miransari and Smith [40]; Lulai et al. [41]; Zhihui et al. [23]). Primartly indole-3-acetic acid (IAA) and then bio-active cytokinins are pointed (Lulai et al. [41]). Indeed, according to Hartmann et al. [39], cytokinins play essential role in terminating tuber bud dormancy and gibberellins interacts with cytokinin to break dormancy. Moreover, both promote earlier sprouting. These phenomena would be more active in the buds of the top and would produce efficient quantities of these hormones there. Also, laminas resulting from these buds of the top are slightly longer (22.90 cm) and wider (22.54 cm), while those derived from buds of the base are less long (20.75 cm) and wide (20 cm). But, petioles and leaves derived from bud of the middle are longer (47.73 cm), while petioles and leaves derived from bud of the base are slightly less long (40.58 cm). Plants resulted from bud of the top produced, in average, one unit more of tubers (4). This strong stimulating capacity of the apex has also been demonstrated in *in-vitro* culture of *Colocasia esculenta* L. Droh [38] established that explants from the terminal (apical) bud are 80 % more capable of resuming than the axillary buds at 20 %. Similarly, these apical buds resume faster (after a week) and develop more quickly. In fact, the seedlings reach the one-leaf stage after two weeks for the terminal bud and four weeks for the axillary buds. Also, Bogale [42] found that mean number of shoots and mean length of shoot from corm apical shoot were higher than from sprout tip (newly sprouted axillary shoot). These differences might be due to higher phytohormone concentrations in the vegetative organs resulting from buds of the top of the tuber. Auxins and cytokinins stimulate plant growth and development (Sosnowski et al. [43]). Auxins activate tuber initiation, growth and sprouting processes in potato (Kolachevskaya et al. [44]).

Another type of variation was revealed at the bud level. Indeed, large buds differed significantly to very significantly from small ones for all parameters, except for the number of tubers per plant. The large buds sprouted earlier and the resulting plants showed longer, wider laminas, longer petioles and leaves.

Other authors have shown the increasing effect of increasing the size of the bulb. This is the case of Gebre et al. [45] who observed that increasing corm size increased significantly plant height, leaf area index, corm and cormels number/plant, corm and cormels yield/ha of taro. Vollbrecht et al. [46] found that meristems are shortened when they do not manifest the function of the kn1 gene playing a role in shoot apical meristem maintenance. Thus large buds, in taro, could be expected to contain particular genes whose expression would generate efficient amounts of compounds stimulating germination, growth and development. This is also the case of Osundare and Ayodele [29] who found that the size of planting or propagation materials (corm, cormels and split corm) did not significantly influence days of emergence (sprouting) of Cocoyam (*Xanthosoma mafafa*). But, cormels (120 g) influenced significantly higher the growth (leaf length and width and plant height) and yield performance (number of cormels), contrary to corm (200 g) and split corm (60 g). The opposite observation was made by Acedo et al. [47] who revealed that Philippine taro [*Colocasia esculenta* (L.) Schott] presented more explants with bud growth as shoot tip size decreased and shoot-forming significantly increase with decreased explant size. The quarter shoot tips explants produced the highest number of shoot-forming explants (80-100 %) as compared to half shoot tips explants (50-60 %) and whole shoot tips explants (20-40 %). These authors also revealed that, regardless of cultivar, much more shoots from half and quarter shoot tip explants formed roots than whole shoot tip explants and, in addition, roots from quarter shoot tip explants are longest.

Concerning time, findings of Acedo et al. [47] were contrasted. Indeed, bud growth set in earlier (6 - 7 days) in half and quarter shoot tips, while, the whole shoot tips took the longest time (25 days) to initiate shoot. Conversely, the time period to root formation was delayed in split shoot tips by 2-10 days relative to that of whole shoot tips. The effect of the size was highlighted by Lazare and Zaccai [22] in *Lilium longiflorum*, a bulbous plant, where different flowering pathways are regulated by bulb size.

Regarding the singular differences related to the localization d and the size of the bud in each of the varieties studied, similarities with the global effects are observed. Indeed, on the one hand, differences revealed in global bud localization effects were corroborated for lamina width in CD and lamina width, petiole length, total leaf length, number of tubers per plant in X5. Similarly, for lamina width and number of tubers per plant in global effects, in these two varieties, CD and X5, and for these parameters, buds localized in the top generated the highest values. For lamina width in CD and X5, plants resulting from top buds showed the widest laminas. In X5, this same type of plants has the longest petioles and leaves; they also produced the highest number of tubers.

On the other hand, differences revealed between small and large buds in global bud size effects were corroborated for lamina length in CD and X5, lamina length, lamina width and total leaf length in X1, lamina length, lamina width, total leaf length, number of tubers per plant in X4, the days to emergence, lamina length, lamina width, petiole length, total leaf length, number of tubers per plant in C3. Similarly, for days to emergence, limb length, lamina width, petiole length, total leaf length in global effects, in the five varieties, C3, CD, X1, X4 and X5, and for these parameters, large bud germinated earlier; the resulting plants have the longest and widest laminas, the longest petioles and leaves, and have produced the greatest number of tubers.

5. CONCLUSION

The overall effects of variety, bud localization and bud size, on the one hand, and the particular effects of localization and size in each of the five taro varieties, on the other hand, were estimated on six parameters.

Overall, bud of the top germinated earlier (26 days), generated longer (22.90 cm) and wider (22.54 cm) limbs and more tubers. Conversely, petioles and leaves derived from bud of the middle are longer. Also the large buds sprouted earlier (24.82 days) and generated longer (24.09 cm), wider (23.48 cm) laminas, longer petioles (45.32 cm) and leaves (69.43 cm).

Furthermore, in individual varieties, on the one hand, plants grown from buds of the top presented the widest laminas (19.89 and 25.58 cm), in CD and X5, the longest petioles and leaves (41.44 and 67.83 cm) and, in addition, produced the greatest number (3.35) of tubers, in X5. On the other hand, large bud germinated earlier (25.20 days) in C3 and generated the longest laminas (19.71 to 26.84 cm) in the five varieties, wide laminas (21.96 to 27.32 cm) in X1, X4, C3, the longest petioles (46.57 cm) in C3, longest leaves (61.30 to 79.73 cm) in C3, X1, X4 and the greatest number (3 to 6.23) of tubers in C3 and X4.

Consequently, leaves of X5 emerged earlier (23 days).

Also, limb of X1, X4, X5 are longer (22 to 25 cm) and wider (20 to 25 cm) than those of C3 and CD (19 cm). Petiole and leave are longer (51 and 74.25 cm, respectively) in X1. In contrast, *Colocasia* produced more tubers.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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