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Impact of Fruit Order on Cucurbits Yield Components: A Case of *Lagenaria siceraria* (Molina) Standl

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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

Lagenaria siceraria is a trendy plant in Ivory Coast for its seeds. However, production of this plant remains relatively low. One of the underlying reasons for poor yields is poor control of crop techniques. This study is part of the improvement of *L. siceraria* production. It was conducted on the experimental farm of Nangui Abrogoua University in Abidjan. The study focused on the effect of fruit order on agronomic parameters related to fruits and seeds. To this end, a series of experiments was conducted. Fruits formed on the same plant were classified into three groups: J0 for the first generation, J8 for the second and J15 for the third generation. The results obtained indicate that for

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all agronomic parameters, the weight of the fruit (PoFr), the volume of the fruit (VoFr), the volume of the seed lodge (VLGr), the number of seeds per fruit (NoGr), the weight of 100 seeds (P100), the highest values are obtained for fruits of the first generation of fruit (J0). Thus, the fruits that appear first have a better agronomic quality. Farmers should use seeds from first-generation fruits for planting.

Keywords: Order of appearance; improvement; production.

1. INTRODUCTION

Food security in Africa is threatened by climate change, reduced arable land, and a growing population. Local genetic resources can enhance food security. (Chimonyo and Modi, 2013). Progress in all areas is achieved when people have food resources in quality and quantity (Zoro Bi et al*.,* 2003). More needs to be done to ensure food self-sufficiency and alleviate poverty. This requires the use of appropriate strategies specific to each community. One of these strategies is promoting and enhancing so-called 'minor' local products. These crops are grown in different traditional production systems or villages. In developing countries, one of the ways to achieve food security is through exploiting and developing local resources. Thus, it is possible to associate local crops such as cucurbitaceous with cash crops.

The oilseed type of Cucurbitaceae is commonly referred to as "Pistachios" in Côte d'Ivoire (Zoro Bi et al*.,* 2003) or "Egussi" (Achigan et al*.,* 2006). They are an essential part of the food and culinary habits of the people who cultivate them in both rural and urban areas in Côte d'Ivoire. The almonds extracted from the peeled seeds are reduced into a paste to prepare the sauce "pistachio". It is a trendy sauce during large ceremonies of widespread rejoicing (Zoro Bi et al*.,* 2003). In addition, these fines have medicinal (Brdar-Jokanović et al*.,* 2024; Roopan et al*.,* 2016; Dheeraj et al*.,* 2019) and nutritional value (Loukou et al*.,* 2007). Moreover, they are the subject of a flourishing trade on local markets, with an average price throughout the year of around 2.5 USD per kilogram of husked seeds (PIC, 2015). It is a source of financial resources for the family unit. Despite all these benefits and advantages, cucurbits are neglected. Several reasons could justify this neglect, such as the lack of a specific agricultural policy, difficulties in financing and guiding farmers, and the absence of scientific data and reliable statistical information. It is in this context that a research project was initiated. Investigations revealed the existence of 5 species cultivated in Côte d'Ivoire, including *Lagenaria siceraria* (Molina) Standl. It is one of the most widespread and abundant species. In addition, the production cycle of this species is short and post-harvest treatments are easy (Achigan et al*.,* 2006).

However, production of *L. siceraria* remains relatively low. One of the underlying reasons for poor yields is poor crop technique control. This study assessed the importance of the influence of horticultural treatments on production. Indeed, the research hypothesis is that the order of fruit appearance affects the components of *L. siceraria* yield. Indeed, the appearance of fruits is staggered over time; it is therefore worth questioning its impact on the fruit's quality and that of the seeds.

The overall objective of this study is to improve *L. siceraria* production. Three specific objectives are addressed: (i) Determine the effect of fruit order on various parameters of *L. siceraria*; (ii) Compare the effect of fruit order on different parameters of *L. siceraria*.

2. MATERIALS AND METHODS

2.1 Study Site

The trials took place during the high rainy season from April to July. They took place at the Nangui Abrogoua University Experimental Farm located between 5° 17' and 5° 31' N latitude and between 3° 45' and 4° 22' W longitude. The average annual temperatures of Abidjan are between 26 and 31°C. Precipitation is generally high, ranging from 1400 to 2400 mm. Abidjan is under the influence of the humid tropical climate with four seasons. A minor dry season (January, February), a sizeable rainy season (March, July), a significant dry season (August, September, October) and a minor rainy season (November, December). Dry seasons are mild because they are tempered by sea breezes (Avit et al*.,* 1999). The test site is heavily anthropized and characterized by deep, sandy clay-sand soils (Zoro Bi et al*.,* 2003). Highly artificial vegetation with a fallow land and a relic of the Banco forest.

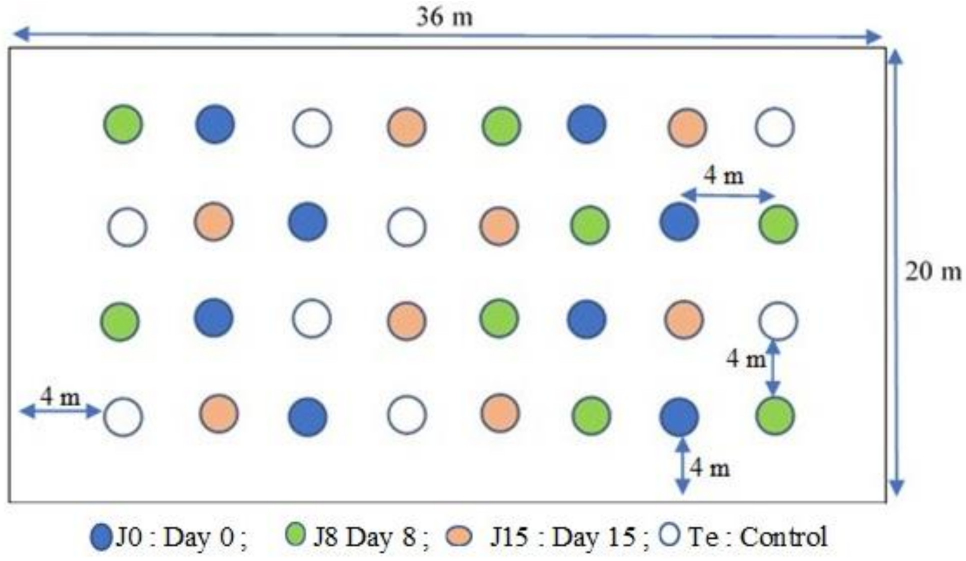

Fig. 1. Experimental set-up to study the effect of the order of appearance of *L. siceraria* berries

The plant material used in this study comes from *Lagenaria siceraria* varieties grown with cap seeds. The seeds come from the collection of the Laboratory of Functional Genomics and Genetic Improvement (LAGEFAGE) of the Nangui Abrogoua University. A series of experiments was conducted from March to August 2021.The experimental design adopted is a complete random block with eight repetitions. The seeding points are 4 m apart (Fig. 1). A total of 32 plants were followed per block of seedlings, or 256 plants.

To study the influence of the order of appearance of fruits, we limit the number of fruits carried by all treated plants to six. For each plant, three generations of fruit are selected. The first generation is J0, the second generation fruits are J8, and finally, the third generation corresponds to J15. The different periods were chosen because of the development cycle of *L. siceraria*. The first female flowers usually appear around 30 days after sowing.

The six fruits are composed of the first two fruits formed on the plant (J0), the two fruits formed eight days after the first (J8) and the two fruits formed 15 days after the first fruits (J15). Once the number of fixed fruits per generation is reached, all other fruits that appear during the set periods and those that appear between two periods are eliminated. For the control plants, the fruits were labelled according to the same time intervals as the plants with a fixed number of fruits.

In order to evaluate the impact of fruit-order regulation on fruit yield, seven agronomic parameters characterizing berries and seeds were selected from cucurbits descriptors (Koffi et al*.,* 2009): Fruit weight (PoFr), Fruit volume (VoFr), Seed box volume (VLGr), Number of seeds per fruit (NoGr), Weight of 100 seeds (P100), Dry Seed Weight (PoGr) and Harvest Index (I*n*Re).

2.2 Data Analysis

A comparison of averages between different generations was made for each parameter studied. Variance analyses with a classification factor (ANOVA 1) were used to compare the influence of the order of appearance of different generations of fruits on all fruit parameters. These analyses. They start by checking the homogeneity of the variances between samples. When this condition is met, ANOVA is performed. When a significant difference is revealed between the different generations of fruit for a given parameter (P<0.05), the Least Significant Difference test (LSD) is performed. This test identifies the generation(s) that differ significantly from each other (Dagnelie, 1998). The Kruskal-Wallis test is performed in the case of an inequality of variances. The Kruskal-Wallis test was performed for seed box volume, dry seed weight and crop index characteristics. All tests were performed using R software version 3.1.

3. RESULTS AND DISCUSSION

3.1 Results

Analysis of Yield Parameters Based on the Order of Fruit Appearance:

The analysis of variance showed a significant effect of the order of fruit appearance on several parameters: fruit weight (PoFr) (F=6.59; P<0.001), fruit volume (VoFr) (F=26.17; P<0.001), number of seeds per fruit (NoGr) (F=23.63; P<0.001), and the weight of 100 seeds (P100) (F=17.39; P<0.001) as presented in Table 1.

In terms of fruit weight, the LSD test showed that the first generation fruits of the control plants (J0T), the first generation fruits (J0) and the second generation fruits (J8) from the fixed number of fruit bearing plants had statistically identical masses. Moreover, these fruits have possessed the highest masses among all the fruits of generations. These fruits are followed by the third generation fruits obtained from the plants whose number of fruits is fixed (J15) and the second generation of control plants (J8T) whose masses were similar and were greater than the mass of the fruits of the third generation of control plants (J15T). Within the same generation of fruit, the fruits of plants whose number is fixed had masses that proved superior to the masses of the control plants except for the first generations of fruits, or the masses were the same. The LSD test showed that the volumes of first generation (J0) and second generation (J8) fruit from a fixed number fruit-bearing plants and the volumes of first generation fruit control plants (J0T) had identical values. These values are higher than the third generation fruit volumes from plants with a fixed number of fruits (J15) and second generation fruit volumes from control plants (J8T), which were, in turn, higher than the fruit volumes of the third generation control plants (J8T). Considering the fruit volumes of the plants within the same generation, the plants with the number of fruits determined obtained fruit volumes higher than the fruits of the control plants for the second and third generation of fruits. However, for the first generation of fruits, J0 and J0T fruit volumes were the same.

For the number of seeds per fruit, the LSD test revealed that the first generation (J0) and the second generation (J8) from plants with a fixed number of fruits contained the most seeds. They were followed by first (J0T) and second (J8T) generation fruit from control plants and third generation fruit from plants with a fixed number of fruits (J15). Finally, the fruits of the third generation from the control plants (J15T) were those in which the fewest seeds were counted. In addition, the number of seeds obtained per fruit was higher in plants with a fixed number of fruits than in control plants within the same generation.

For the weight of 100 seeds, the LSD test showed that the heaviest 100 seeds were those from first-generation fruits from plants with a fixed number of fruits (J0). The 100 seeds obtained from the second generation (J8) and third generation (J15) fruits from plants with a fixed number of fruits, as well as those obtained from fruits of first-generation control plants (J0T), had masses lower than the mass of 100 seeds from the first generation (J0) fruits but higher than the mass of second (J8T) and third generation (J15T) fruits from control plants. However, the weight of 100 seeds of fruits of the second generation of control plants (J8T) was higher than that of 100 seeds of fruits of the third generation of control plants.

For the characters mentioned above, the LSD test revealed that, in general, the average of these characters decreases with the order of appearance of the fruits.

The row-based Kruskal-Wallis test revealed a significant effect of fruit order on seed box volume (VLGR) (Chi-square=25.04 ; P<0.001) on dry seed weight (PoGr) (Chi-carre= 52.33 ; P<0.001) and the harvest index (InRe) (Chi-carre=27.48 ; P<0.001). It was found that the first generation of fruit from control plants had the highest values in terms of volume of seed box. These fruits were followed by the first-generation fruit from plants with a fixed number of fruits (J0), which were in turn followed by the second-generation fruit (J8). The volume of the second-generation fruit (J8T) seed box was lower than that of the second-generation fruit (J8) but higher than the volume of the cruise fruit (J15). These latter fruits, on the other hand, had boxes whose volumes were higher than the volumes of the fruit box of the third generation of control plants (J15T).

For the weight of dry seeds, analysis of the results revealed that seeds from first generation (J0) fruits were the heaviest. These seeds are then followed by the second generation (J8) seeds and the dry seeds of the first generation of control plants (J0T). These dry seeds of the

Table 1. Average values (standard deviation) of agronomic parameters of fruits and seeds according to the order of appearance of the fruits

Caractères	J0	J8	J15	J0T	J8T	J15T	*P*
PoFr (g)	1956±333.48[a]	1846±272.41[a]	1200±367.42[b]	1773±260.63[a]	1400±367.42[b]	627±265.09[c]	<0.001
VoFr (cm^3)	1427.49±332.24[a]	1371.35±253.28[a]	1093.33±308.73[b]	1297.39±254.9[a]	985.72±194.98[b]	616.85±126.88[c]	<0.001
VLGR (cm^3)	750.14±261.19[b]	681.07±150.49[c]	503.78±182.67[e]	818.33±308.73[a]	590.7±141.29[d]	317.4±117.0l[f]	<0.001
NoGr	335.25±56.29[a]	297.19±53.4[a]	190.94±87.94[b]	202.63±66.26[b]	187±49 .24[b]	128.13±46.38[c]	<0.001
P100 (g)	23.26±4.41[a]	20.13±2.9[b]	17.52±4.21[bc]	19.14±3.33[b]	15.51±3.07[c]	11.98±3.55[d]	<0.001
PoGr (g)	78.15±17.61[a]	59.41±10.78[b]	35.05±20.5[d]	37.43±9.07[c]	28.29±8.61[e]	15.67±8.28[f]	<0.001
*In*Re	0.04±0.008[a]	0.033±0.008[b]	0.029±0.015[c]	0.022±0.006[e]	0.022±0.013[f]	0.026±0.009[d]	<0.001

NB: The averages for the same letter in a line do not differ significantly at P=0.05

J0: first generation. J8: second generation. J15: third generation. J0T: first control generation. J8T: Eouxian control generation. J15T: third generation control. PoFr: weight of fruit. VoFr: volume of fruit. VLGr: volume of seed box. NoGr: number of seeds per fruit. P100: weight of 100 grains. PoGr: weight of dry seeds. InRe: yield index control plants are followed by dry seeds from the third-generation fruits of the fixed number of fruits (J15), which are of greater masses than the dry seeds from the second generation of control plants (J8T). These latter are heavier than the dry seeds obtained from the fruits of the third generation of control plants (J15T).

As for the harvest index, analysis of the results showed that the first generation (D0) fruits had the highest value. These were followed by second-generation fruit (D8), which had a higher harvest index than third-generation fruit (D15). The harvest index of third-generation fruit from plants with a fixed number of fruits (J15) was higher than that of third-generation fruit from control plants (J15T), which in turn was higher than that of first-generation fruit from control plants (J0T). Finally, second-generation fruit from control plants (J8T) had the lowest harvest index value of all the fruit.

4. DISCUSSION

This study, carried out in a natural environment, aimed to identify the optimum fruit load for obtaining fruit and seeds with the best agronomic qualities. The results relating to the agronomic parameters of *L. siceraria* showed that the fruits of the first generation (J0) have the best agronomic values. These results could be explained by the fact that these fruits are the first to be formed. At this precise moment, the plant is in total growth, and many nutrients are mobilised and available. By the second generation (D8), the plant is halfway through its life cycle, generally lasting 90 to 120 days. For the fruit to grow, it must continue to receive food from the mother plant. By this time, however, a large proportion of the nutrients had already been mobilised for the first fruits. Nutrient availability becomes increasingly inadequate for third generation fruit. This explains why they have the lowest values. These results are similar to those obtained by K'Opondo (2011), who observed that in Cleome gynandia, the lower fruits contained the heaviest seeds of all the fruits on the plant. These fruits were followed by intermediate fruits, producing heavier seeds than those from the top fruits.

In addition, the values of the agronomic parameters of the fruit and seeds were generally higher with the fruit harvested at the three target times (J0, J8 and J15) compared with the fruit and seeds of the same generations of the control plants (J0T, J8T and J15T). This result could be explained by the fact that the fruit load is more significant on the control plants. As a result, the nutrients required for fruit development are distributed among more individuals than in the target plants, for which the maximum fruit load is six. In fact, it has been shown that *L. siceraria* plants have a fruit load varying from 2 to 15 (Achigan, 2006). Therefore, there is a negative correlation between a plant's high number of fruits and the various agronomic parameters considered in this study. When the fruit load is high at the plant level, this hurts the agronomic parameters of the fruits as well as those of the seeds of the *L. siceraria* plant bearing these fruits.

5. CONCLUSION

The present study has generally shown that the order in which fruits appear on the plant affects yield components, germination percentage and vigour of *L. siceraria* seedlings. The results indicate that the fruits of the first generation (J0) have the best agronomic value. In addition, seeds from these fruits are heavier (23.26±4.41 g for J0; 20.13±2.91 g for J8 and 17.52±4.21 g for J15). This finding, therefore, shows that the time at which the fruits appear on the plant is a significant factor in determining fruit quality.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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