



ISSN: 0976-3376

Available Online at <http://www.journalajst.com>

ASIAN JOURNAL OF
SCIENCE AND TECHNOLOGY

Asian Journal of Science and Technology
Vol. 13, Issue, 11, pp.12238-12245, November, 2022

RESEARCHARTICLE

CULTIVATION, POST-HARVEST CONSERVATION, MARKETING AND IDENTIFICATION OF WATERMELON (*CITRULLUS LANATUS*) VARIETIES IN THREE PRODUCTION ZONES IN CÔTE D'IVOIRE

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ARTICLE INFO

Article History:

Received 15th August, 2022

Received in revised form

19th September, 2022

Accepted 24th October, 2022

Published online 30th November, 2022

Keywords:

Survey, Production, Kaolack variety, Sugar Baby Variety, post-harvest Conservation, Watermelon sales, Côte d'Ivoire.

ABSTRACT

Watermelon is a plant with great agronomic and economic potential. However, in Côte d'Ivoire, very few studies on cultivation practices, post-harvest conservation, marketing and identification of existing varieties have been conducted. The objective of this study is to acquire a better scientific knowledge of the production of watermelon in Côte d'Ivoire. To do this, a non-exhaustive survey using the snowball method was conducted among 127 producers, including 54 in Bassam, 42 in Jacqueline and 31 in Divo. The results showed that 72.22%, 64, 28% and 100% of the producers in Bassam, Jacqueline and Divo respectively are male, with a majority of them aged between 31-50 years. The most cultivated watermelon variety is Kaolack with 66.10% of its production in Jacqueline and 72.97% in Bassam and Divo. The months of sowing are April (35%) or September (29%) in Divo and March (16%) or August (24%) in Bassam and Jacqueline. More than 60% of producers estimate that the watermelon reaches maturity two months after sowing. The fruit is sold either directly at the market or with wholesalers. This study highlighted the cultivation practices and the economic importance of watermelon marketing in the producers' portfolio.

Citation: Gbraguhé Désirée Victoire, Adjouman Yao Désiré, Adou Marc and Tetchi Fabrice Achille, 2022. "Cultivation, post-harvest conservation, marketing and identification of watermelon (*citrullus lanatus*) varieties in three production zones in Côte d'Ivoire", *Asian Journal of Science and Technology*, 13, (11), 12238-12245.

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INTRODUCTION

Watermelon (*Citrullus lanatus*) is a plant belonging to the family Cucurbitaceae and the order Cucurbitales. According to some authors, it is native to North Africa (Paris, 2015) while others locate its origin in West Africa (G. Chomiccki & SS Renner, 2015). It is a good source for all human consumption needs. This is because it contains basic nutritional compounds of the human body and other essential nutrients that prevent human health problems such as cancer, stroke, high blood pressure, heart attack and other cardiovascular diseases (SK Chogou et al, 2019). It is a fruit cultivated today in different regions of the world with several varieties remarkable for their rather large weight and volume (USDA, 1998). The world production is estimated at more than 166 million tons in 2018 according to data from the Food and Agriculture Organization of the United Nations (FAO, 2020). It accounts for about 9.5% of the total fruit production in the world and nearly 83.7% of its production is in Asia.

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China is the leading producer of watermelon with over half of the world's production (AR Davis et al, 2008). Far behind, in second position, is Turkey. Because of the importance of watermelon as a food, Turkey has pursued an agricultural development policy that has made this plant a source of foreign currency for producers. Also, this country is the leader in the conservation techniques of the phylogenetic resources of this species (I. Solmaz & N. Sari, 2009). Considering the numerous nutritional and economic advantages of watermelon, some African countries have started to produce the fruit and record an appreciable annual production of watermelon; we can mention Senegal with 224 000 tons, Sudan with 143 000 tons, Cameroon with 73 800 tons, Somalia with 28 000 tons, and the United States with 28 000 tons and Mauritania with 11,000 tons (F. Kakpovi, 2017). Watermelon was also introduced into the rural agricultural system in Nigeria two decades ago (WO Oyediran et al, 2018) and its total production in 2003 was 175,340 tons (OT Adojutelegan et al, 2015). Watermelon cultivation is recent in Guinea, dating back to the 1970s (USAID, 2006).

It is also recent in Burkina Faso, which has embarked on its production (PI Yanogo *et al.*, 2021). In Benin, watermelon production still seems marginal, however, it is of increasing interest to producers (F. Kakpovi, 2017). While watermelon cultivation is gaining ground on the African continent and worldwide, in Côte d'Ivoire, it is still carried out in an archaic manner on small areas by small market gardeners mainly for urban consumption. As a result, it occupies only a secondary place in the gardens of Ivorian market gardeners (Declert, 1990). Whereas today, with the change in eating habits, urban dwellers are consuming more watermelon (INSD, 2018). This study set out to highlight the current varieties of watermelon grown in Côte d'Ivoire, the post-harvest conservation methods used by producers, and to highlight the opportunity that watermelon cultivation represents for production stakeholders.

MATERIALS AND METHODS

METHOD

Following a pre-survey (survey of watermelon sellers in Abidjan city), three cities in Côte d'Ivoire, namely Bassam, Divo and Jacqueline, were identified as watermelon production areas in Côte d'Ivoire. Thus, these production areas were the site of the surveys for this study. Watermelon producers in the villages of these three towns were interviewed. In Bassam, the villages that were surveyed were Modesse, Mondoukou, Yakassé 1, Voie de Vitré, 8 Kilo and 3 Kilo. In Jacqueline, the villages where producers were interviewed are N'Djem, Adjoumanga, Jacqueline, Sassako and Grand Jacque. Finally, in Divo, the villages are 5 Kilo, Yobouekro, Data, Dagrom, Gazaville and Tabledoukou.

The non-exhaustive survey using the snowball sampling method described by author G. Fokou *et al.*, (2016) was used. It consisted of travelling through the villages where watermelon is grown in the different study sites to collect data from producers in the form of semi-structured interviews. This method made it possible to interview 127 producers, including 54 in Bassam, 42 in Jacqueline and 31 in Divo (Table 1). The survey took place from August 2 to September 10, 2021. The questionnaires covered, among other things, the socio-demographic characteristics of the respondents (gender, age, level of education) and also the reputation of watermelon (the varieties of watermelon produced, production practices, methods and time of post-harvest conservation, marketing methods, selling prices and the question of profitability of the crop) among the producers

Presentation of the study sites

Bassam: Bassam or Grand-Bassam is located in the South-Comoé region with an area of 13,000 ha (hectare). The climate is tropical humid with an annual rainfall of 2100 mm spread over the year. The hydrographic network of Grand-Bassam is very developed with an impressive lagoon system (Paradis, 1988). Apart from this lagoon system, the Grand Bassam region borders the Atlantic Ocean and is crossed by the Comoé River. The soil according to DE Sehi, (2013) is essentially ferralitic. This soil is characterized by coarse sand sediments which are littoral sands and lagoon edge sands. Mud or mangrove soils are also found.

Table 1. Distribution of producers surveyed according to study sites

Cities	Villages	Number of people surveyed
Bassam	Modesse	08
	Mondoukou	05
	Yakassé 1	13
	Voie de Vitré	09
	8 Kilo	11
	3 Kilo	08
Total/City		54
Jacquerville	N'Djem	07
	Adjoumanga	09
	Jacquerville	13
	Sassako	11
	Grand-Jacques	02
Total/City		42
Divo	5 Kilo	02
	Yobouekro	03
	Data	07
	Dagrom	11
	Gazaville	05
	Tabledoukou	03
Total/City		31
GENERAL TOTAL		127

The vegetation of Grand- Bassam is characterized by a forest environment, several stretches of savanna dotted with patches of forest observable in some places (DE Sehi, 2013).

Divo: Located in the forested southwest of Côte d'Ivoire, Divo has been the capital of the Lôh-Djiboua region since January 15, 1997 (DD Ourega & OD Gbocho, 2021).

The city covers an area of approximately 3,577 km². The climate of the Divo area is that of the Atrean with an equatorial regime, which is a transitional equatorial climate. The average monthly rainfall in the department ranges from 232.59 mm in June (main rainy season) to 20.39 mm in January (main dry season) (KSA Yao, 2020).

Jacquerville: Jacqueline is one of the coastal cities of the South-East of Côte d'Ivoire and of the Grand Pont region. Located in the southern part of the lagoon region, the department of Jacqueline extends its 3,205 km² on the median parts of the coastline and the Ebrié lagoon. The climate is humid tropical, characterized by four seasons (two rainy seasons, two dry seasons) with a rainfall of 2,500 mm per year. The relief is flat and essentially sandy from the sea to the lagoon, clayey and escarpment in the northern part of the lagoon (R. Mylene, 1996).

Statistical analysis: The different information collected on the survey forms was entered with the Epi-data 3.1 software and then transferred to the SPSS version 20.0 software to constitute the database. The numbers were calculated for the quantitative variables as well as the percentages. Statistical analyses were then performed using XlStat software version 2014.5.03.

In addition, the Chi-2 test was used to test the relationships between the categorical variables at the 0.05 significance level. When there was a significant difference, the Marascuilo procedure of performing pairwise comparison tests for all pairs of proportions was then employed (Marascuilo, 1988). This allowed for the identification of proportions that differed from each other.

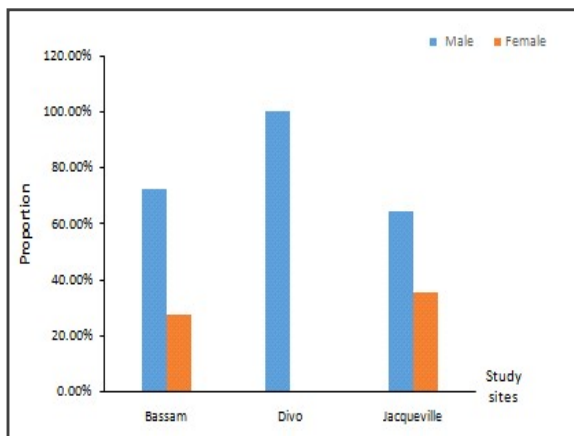


Figure 1. Distribution of producers by gender

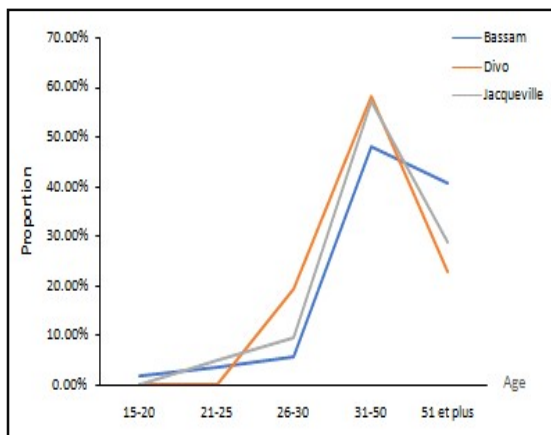


Figure 2. Distribution of producers by age

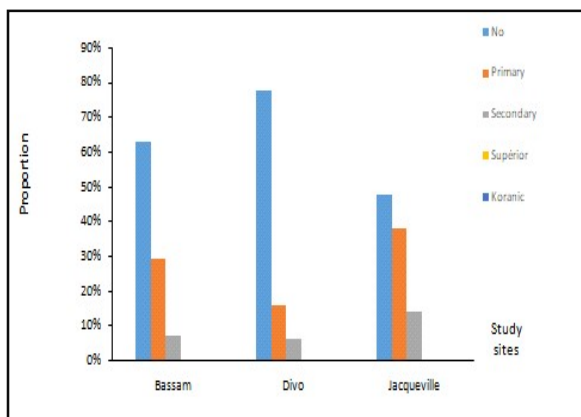


Figure 3. Distribution of producers by education level

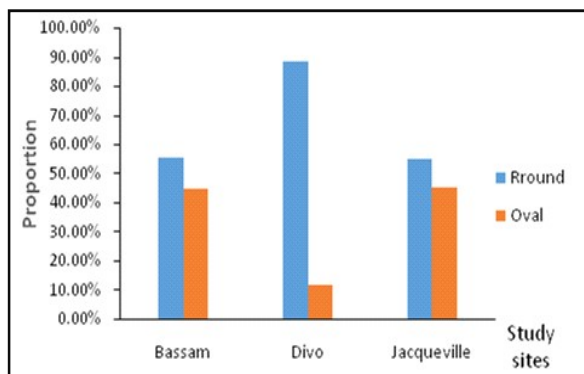


Figure 4. Proportion of watermelon varieties grown by shape

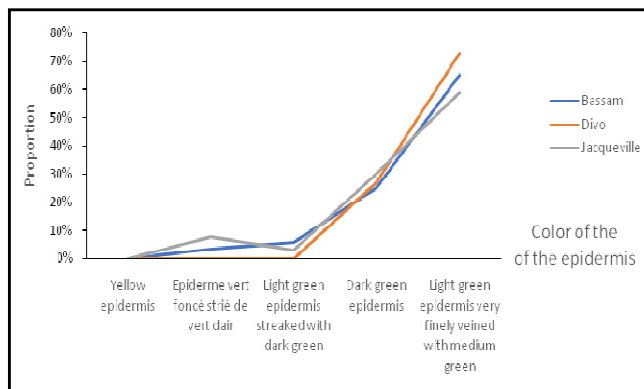


Figure 5. Proportion of watermelon varieties grown by skin color

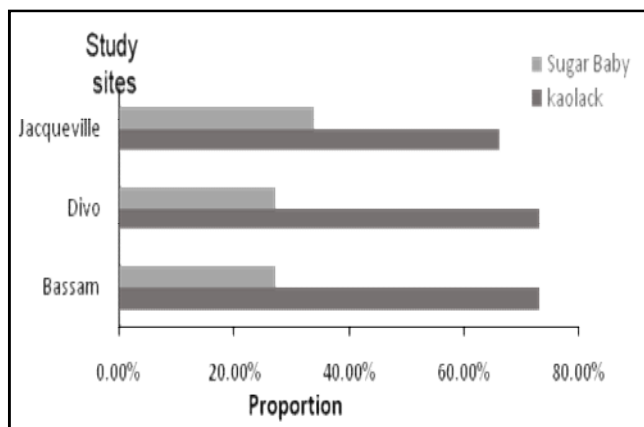


Figure 6. Proportion of watermelon varieties grown

RESULTS

Socio-demographic characteristics of producers: Figures 1, 2 and 3 show the socio-demographic characteristics of the respondents. Significant differences ($P < 0.05$) were observed in all socio-demographic variables considered in the study.

The survey data show that 100% of watermelon producers in Divo are male. In contrast to Divo, Bassam and Jacquville have more than 25% female watermelon growers (Figure 1). The results also reveal that more than 50% of the producers in the Divo and Jacquville areas are between 31-50 years old. However, 23% of producers in Divo and 29% of producers in Jacquville respectively are over 50 years old (Figure 2). The Bassam area has significantly the same proportion of producers aged between 31-50 years and 41% who are over 50 years old. The level of education of producers also varies from one locality to another (Figure 3). We note that the majority (more than 60%) of producers in Divo and Bassam have no education. However, 16.10% and 6.50% in Divo and Bassam have primary and secondary education respectively. In contrast to Divo and Bassam, the Jacquville zone has less than 50% of producers with no education, 38.1% with primary education and 14.3% with secondary education. The socio-demographic characteristics of the respondents in this study show that all the respondents in Divo and the majority in Bassam and Jacquville were men, while a minority were women. The majority of respondents in the three study areas were between 31-50 years old. The level of education of producers also varied from one study area to another. Over 60% of producers in Divo and Bassam versus less than 50% in Jacquville had no education.

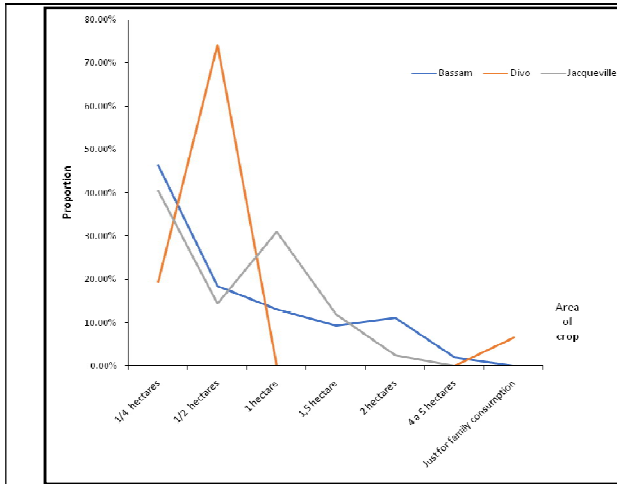


Figure 7. Proportion of area under watermelon

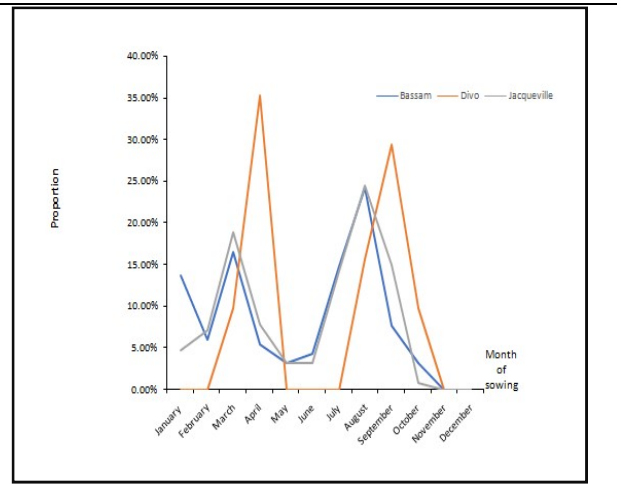


Figure 8. Different months of watermelon cultivation according to producers

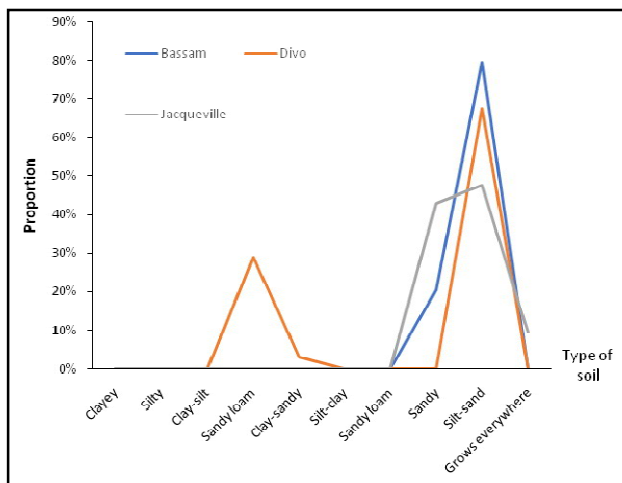


Figure 9. Soils suitable for growing watermelon

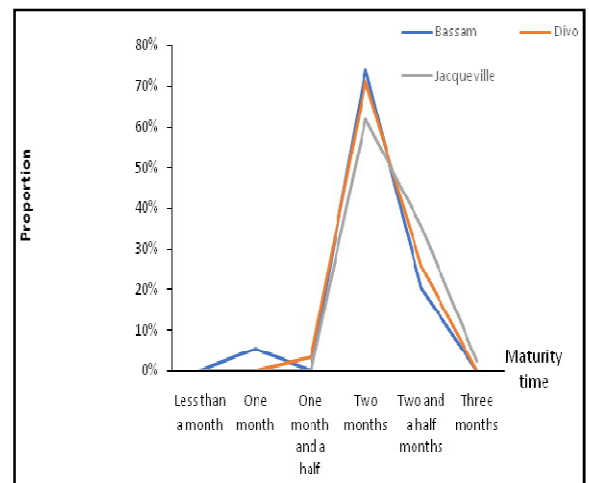


Figure 10. Maturity time of watermelon

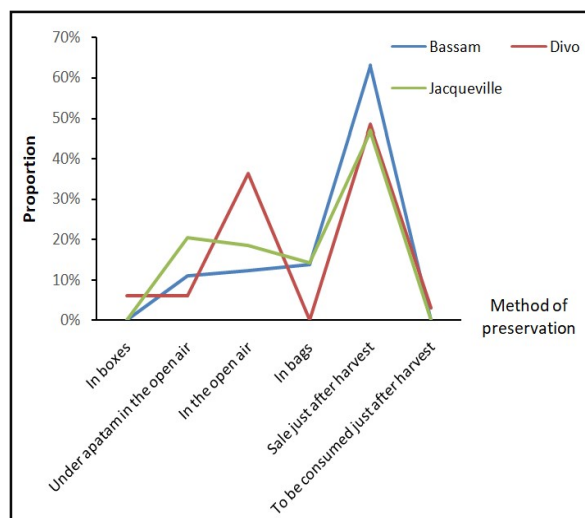


Figure 12. Different ways of storing watermelon

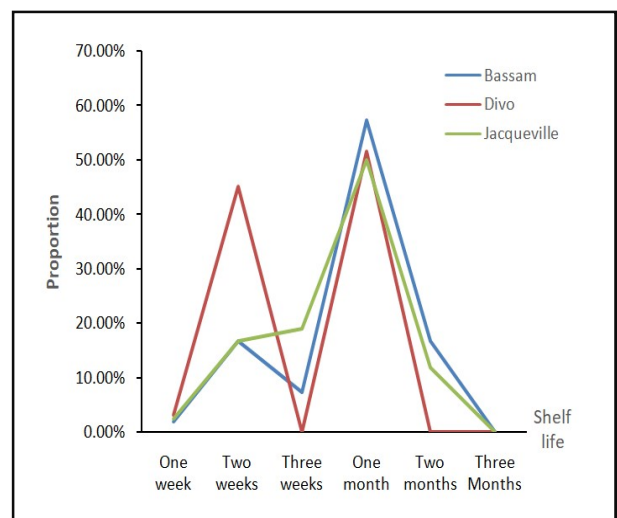


Figure 13. Shelf life of watermelon according to producers

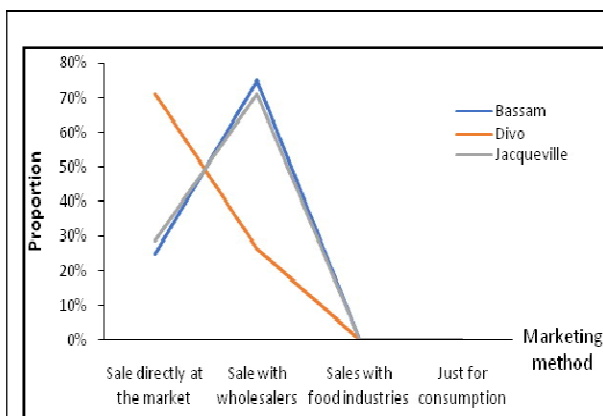


Figure 14. Watermelon marketing methods used by producers

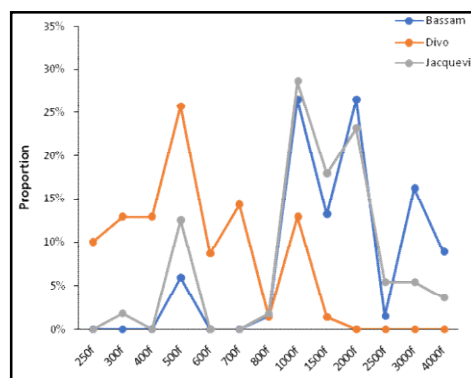


Figure 15. Market price of fruit

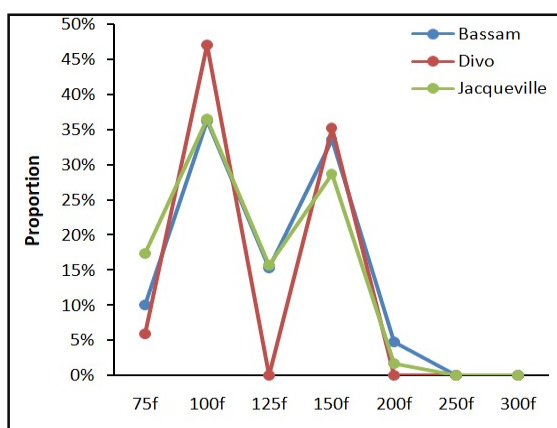


Figure 16. Fruit marketing prices with wholesalers

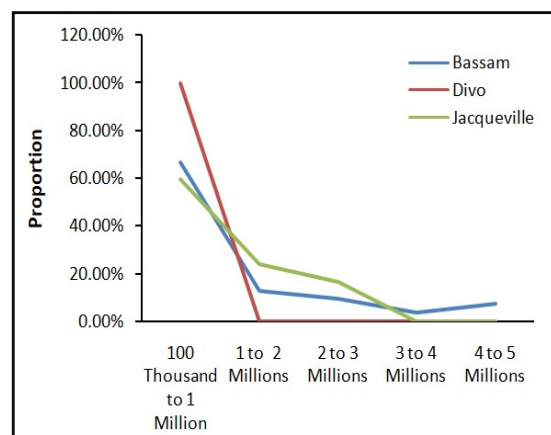


Figure 17. Profitability after marketing the fruit

Characterization of watermelon varieties: Figure 4 shows that in the Bassam zone, producers cultivate round (55.13%) and oval (44.87%) watermelons in the same proportions ($p > 0.05$). However, significant differences ($P < 0.05$) were observed at the level of Jacquville and Divo, which recorded 54.93% and 88.57% of round-shaped watermelons respectively, compared with 45.07% and 11.43% of oval-shaped watermelons respectively.

Table 2. Proportion of watermelon varieties grown according to pulp color and presence or absence of seeds

	Proportion % of watermelon varieties according to the color of the pulp and the presence or not of seeds in the pulp		
	Bassam	Divo	Jacquville
Watermelon varieties with red flesh with seeds	100 %	100 %	100 %

According to Table 2 and Figure 5, in all the study areas, 100% of the producers surveyed cultivate watermelons with a red pulp containing seeds with a dark green or light green skin with a very fine medium green vein. However, the most cultivated are the watermelons with light green skin very finely veined with medium green with 59% of the proportion in Jacquville, 65% of the proportion in Bassam and 73% of the proportion in Divo. Figure 6 shows that Sugar Baby and Kaolack are the varieties grown in the study areas. However, the most widely cultivated variety is Kaolack, with 66.10% of the proportion in Jacquville, and 72.97% of the proportion in Bassam and Divo.

The Sugar Baby and Kaolack varieties are the two watermelon varieties grown by the producers surveyed in the different study areas. However, the cultivar most commonly found among them is the Kaolack variety with red pulp and seeds.

Watermelon cultivation practices : According to figure 7, 46.3% of producers in the town of Bassam generally grow their crop on 1/4 ha; 18.5% on 1/2 ha; 13% on 1 ha; 11.10% on 2 ha; 9.30% on 1.5 ha and 1.9% on large areas (4 to 5 ha). This observation is more or less the same as in the town of Jacquville, which also records 40.5% of producers growing crops on areas of 1/4 ha; 31% on 1 ha; 14.3% on 1/2 ha; 11.9% on 1.5 ha and 2.4% on 2 ha. In contrast to Bassam and Jacquville, in Divo, more than 70% of farmers cultivate on an area of 1/5 ha, 19.40% on 1/4 ha and only a minority (6.5%) cultivate just for family consumption. The results also show that all the study areas have two watermelon planting periods (Figure 8). However, the cultivation periods in the Divo area differ from those in Bassam and Jacquville. According to producers in Divo, the months of April (35%) and September (29%) are the most suitable for watermelon production. However, in Bassam and Jacquville, the months of March (more than 16%) and August (more than 24%) are the most favorable months for watermelon production, according to producers in these areas. Also, some producers (13.80%) in Bassam believe that the crop can be grown in January. This crop is grown mostly on sandy-silty soils. However, in the Divo (29%) and Jacquville (43%) zones, sandy-silty soils are also suitable for cultivation (Figure 9). Figure 10 shows the

time it takes for watermelon to reach maturity after cultivation. Thus, in all the study areas, more than 60% of the producers estimate that watermelon reaches maturity in a minimum period of two months according to the respondents. Also, more than 20% of the respondents indicate a maturity period of two and a half months. Regarding harvesting periods, respondents in the Divo area indicated the months of July and November. The months of May and October were indicated by respondents in Jacqueville and Bassam. However, harvesting begins earlier in Bassam in March (Figure 11). Watermelon cultivation in the different study sites is mostly practiced on small areas with sandy loam or sandy soil texture, either in April and/or September for the Divo area, or in March and/or August for the Bassam and Jacqueville area. Maturity follows after a minimum period of two months or a maximum period of three and a half months.

Post-harvest storage methods and times : Figure 12 shows the different methods of storing watermelon. Thus, 63% of producers in Bassam, 48.50% in Jacqueville and 47% in Divo believe that the safest way for them to benefit from their harvest is to sell the produce immediately after picking. However, if this is not the case, several means are used by them to preserve the fruit. For example, in the Divo area, 36.40% of producers preserve their produce in the open air, while in Bassam and Jacqueville, 11% and 20% respectively use preservation under a patam in the open air, and 12% and 18% respectively of producers preserve their produce in the open air. The different methods of conservation allow more than 50% of the producers in the study areas to keep their products for one month in the traditional way. However, this can vary from two weeks to one month depending on the storage conditions. However, Divo records producers (45.20%) who have shorter storage times (two weeks) (Figure 13). From this study, it appears that producers sell their production directly after harvesting. But in the contrary case several means are used by them for the conservation of the fruit whose shelf life can reach two weeks to one month.

Marketing methods, selling prices and profitability of watermelon cultivation: The results of this survey show a difference in the sale of watermelon in the Divo area and that of Bassam and Jacqueville (Figure 14). In Divo, 73.70% of producers sell their production directly to the market, while 26.30% of producers sell their production to wholesalers. In contrast to Divo, producers in Bassam and Jacqueville (75% and 71.10% respectively) sell their production to wholesalers. However, 25% and 28.90% in Bassam and Jacqueville respectively sell their production directly to the market. With regard to watermelon selling prices (Figure 15 and 16), the results show that, compared to the Bassam and Jacqueville zones where the price of fruit sold directly to the market as a whole is relatively high (500 FCFA, 1000 FCFA, 1500 FCFA, 2000 FCFA and 3000 FCFA), in Divo the selling price of fruit is less expensive (500 FCFA, 700 FCFA and 1000 FCFA). The sale of fruit in the three production zones is done by kilogram (kg). Thus, prices per kg vary between 75 FCFA and 150 FCFA. The commercial practices employed (Figure 17) by all producers in Divo (100%) and more than 60% of producers in Bassam and Jacqueville have enabled them to benefit from an after-sales profit ranging from one hundred thousand to one million. In addition, in Bassam and Jacqueville, some producers managed to make even more profit after selling the fruit. Several methods of marketing watermelon are used by

producers to sell their production. And according to the producers, the commercial practices employed by all of them, allowed them to benefit from a rather reasonable after-sales gain.

DISCUSSION

The results of this study revealed that all respondents (100%) in Divo and the majority in Bassam and Jacqueville (over 70%) were men while a minority were women. This is explained by the fact that men are generally engaged in field work while women are known for their marketing activities. However, the work of (AT Denis *et al.*, 2019) in Cameroon, specifically in Santa, showed a significant involvement of women (30%) in watermelon production. They would therefore be engaged in many activities emanating from watermelon production which could be a positive driver in overall production (Paris, 2015). The results of this study are in agreement with some studies conducted in Nigeria (OT Adojutelegan *et al.*, 2015; WO Oyediran *et al.*, 2016; WO Oyediran *et al.*, 2018). The results also show that the majority of respondents (more than 50% in Divo and Jacqueville and 48% in Bassam) are between 31-50 years old. Some of the respondents in this study (23%, 29%, and 41% in Divo, Jacqueville, and Bassam, respectively) are over 50 years old. These results show more or less a similarity with studies observed by some authors (OC Ajewole, 2015; B. Sarker *et al.*, 2018; AT Denis *et al.*, 2019). These results imply that producers in the active age range are engaged in this activity. Therefore, age plays an important role in farming as it determines the strength of the farmer's ability to perform tedious and rigorous work as defined by certain activities in watermelon farming (SFG Yusuf *et al.*, 2013). The level of education of producers also varied from one location to another. The majority (more than 60%) of producers in Divo and Bassam versus less than 50% in Jacqueville had no education. However, some of the producers surveyed in the three study areas (Divo, Bassam, and Jacqueville) have primary and secondary education, respectively. The lack of education among the majority of producers indicates a high level of illiteracy. This result is attested to by the studies of (AT Denis *et al.*, 2019). However, studies by some authors (OT Adojutelegan *et al.*, 2015; B. Sarker *et al.*, 2018) have observed a population of watermelon growers with high literacy.

It also appears from this work that farmers in the study areas have a particular preference for two watermelon varieties: Sugar Baby and Kaolack. However, the cultivar most frequently encountered by producers is the Kaolack variety. These same cultivars are present in Benin with a dominance of the Kaolack cultivar (CS Kpenavoun & Achigan-Dako, 2015). The work of (CS Kpenavoun & EG Achigan-Dako, 2015) indicates furthermore, that the characteristics of the fruit are a determining guide in the choice of varieties. This assertion is supported by (B. Sarker *et al.*, 2018) in the state of Oklahoma. Also according to studies by (OT Adojutelegan *et al.*, 2015), several watermelon varieties including Sugar Baby and Kaolack were grown in Nigeria but Sugar Baby was the most grown seed (38.1%) compared to other cultivars. Regarding watermelon cultivation practices, the vast majority of producers in the study sites use small areas for watermelon cultivation. However, a minority in Bassam use slightly larger areas. This shows that watermelon production in the study areas is practiced mainly by small farmers with very little

financial means, materials and subsidies from the Ivorian state. This result is in agreement with the studies of (OC Ajewole, 2015) in Benin. According to this study, 51.10% of producers cultivate watermelon on areas ranging from 1.01 ha to 1.5 ha, while only 4.40% cultivate more than 2 ha. Elsewhere in Mali, in the region of Timbuktu studies by (BD Jensen *et al*, 2011) showed that production areas generally ranged from 1.0 to 4.0 ha of producer, but a few reported having more of 10 ha. Two watermelon sowing periods are relatively observed in the three study areas. However, the periods at Divo differ from those at Bassam and Jacquville. Indeed, the months of April and September were recorded for Divo and the months of March and August for Bassam and Jacquville. The work of the authors (BD Jensen *et al*, 2011; J. Shrefler *et al*, 2015) shows that cultivation periods differ from one state to another depending on the climate. Indeed, according to these same authors, watermelon sowing begins in March or April. However, in Mali, sowing begins at the start of the rainy season, usually in mid-July. But near the river, sowing begins in July and continues until August-September when the water level in the river after the rains begins to drop. According to the farmers of the different sites of our study, soils with a sandy-loamy texture are suitable for cultivation but in some cases it can be grown on sandy-loamy or sandy soils. Maturity follows after a minimum period of two months or a maximum period of three and a half months. Thus, the harvest is done in the months of July and November for the Divo area or the months of May and October for the Bassam and Jacquville areas. The fruits grow best on sandy loam soils (Anonymous, 2011; F. Kakpovi, 2017) on sandy loam soils (N. Hamza, 2014; J. Shrefler *et al*, 2015) and in sandy textured soils (BD Jensen *et al*, 2011; J. Shrefler *et al*, 2015). In view of these different types of soils used for growing watermelon, the author (OT Adojutelegan *et al*, 2015) deduces that watermelon can be grown on a wide variety of soils. Therefore, the type of soil cannot affect production. Authors (N. Hamza, 2014; J. Shrefler *et al*, 2015) agree that watermelon can be harvested after two or two and a half months of maturity. According to N. Hamza (2014) the fruits can be harvested about 3 months after maturity. La grande majorité des producteurs sur les sites d'étude écoulent directement leur production juste après récolte. Mais dans le cas contraire plusieurs moyens sont utilisés par ceux-ci pour la conservation du fruit dont la durée de conservation peut atteindre deux semaines à un mois. Ce résultat est conforme aux travaux de (CS Kpenavoun & EG Achigan-Dako, 2015 ; F. Kakpovi, 2017). The marketing practices employed by the producers of Divo which differ from those of Bassam and Jacquville. As a result, several marketing methods with different fixed prices of the fruit are used for the sale of production in these areas. The method used therefore depends on the producer and the quantity of production. And according to the producers, the commercial practices employed by all, allowed the producers to benefit from a fairly reasonable after-sales gain. Therefore the production of watermelon is a profitable activity. This same observation has been made by some authors in various regions of Africa (FGY Shehu *et al*, 2013; CS Kpenavoun & EG Achigan-Dako, 2015; F. Kakpovi, 2017), who claim that watermelon production is a profitable business.

CONCLUSION

This work has made it possible, on the one hand, to highlight the practices of cultivation and post-harvest conservation of

watermelon in three production areas in Côte d'Ivoire and, on the other hand, to shed light on the marketing of watermelon production. The results obtained showed that the production of watermelon is a predominantly male activity. The most widely grown watermelon cultivars according to this study are Kaolack and Sugar Baby. However, Kaolack is the cultivar most produced by all and therefore the most demanded by consumers. Production is either mostly sold directly to the market at prices set at 500 FCFA, 800 FCFA and 1000 FCFA in the case of the Divo area, or sold mainly to wholesalers at prices per kg set at 75 FCFA, 100 FCFA or even 200 FCFA areas of Bassam and Jacquville. Whatever the marketing method used, there is a significant profitability of watermelon production at the level of most producers. However, the sector is confronted with numerous organizational, technical and financial problems which jeopardize its development. It is also necessary to note the highly perishable nature of the fruit, the absence of units of conservation and transformation. However, the promotion of local production of watermelon, the creation of a watermelon sector, the provision of technical and financial support to producers could make the activity competitive in the sub-region and worldwide.

Competing Interests: The authors declare that they have no competing interests.

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