



Article

Performance and Quality Assessment of Emerging “Robusta Coffee” Plantations in Qanater El-Khairia, Egypt.

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<https://doi.org/10.37229/fsa.fjh.2025.12.07>

Future Science Association

Available online free at
www.futurejournals.org

Print ISSN: 2692-5826

Online ISSN: 2692-5834

Received: 9 October 2025

Accepted: 25 November 2025

Published: 7 December 2025

Publisher's Note: FA stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.



Abstract: In recent years, Egypt has witnessed a remarkable expansion of coffee cultivation, particularly *Coffea canephora* (Robusta), which has attracted significant attention in light of the increasing local demand for coffee. This situation highlights the necessity of evaluating the performance of these plantations in terms of productivity and quality. Field and laboratory analyses were conducted to assess the physical characteristics of the beans and compare them with international standards for Robusta coffee. Chemical analyses were also performed to determine caffeine and chlorogenic acid contents, aiming to evaluate the chemical quality relative to global reference values. In addition, molecular genetic profiling was carried out to confirm the identity of the cultivated trees and to document the level of genetic diversity. To clarify the influence of environmental factors on bean quality, a climatic study of the region and comprehensive soil analyses were included. The physical and chemical results revealed highly promising performance, and providing strong evidence for the potential success of producing Egyptian coffee with distinctive attributes. These findings underline the potential sustainability and competitiveness of locally cultivated Robusta coffee under the agro-climatic conditions of Qanater El-Khairia.

Keywords: Robusta coffee; Bean quality; Caffeine content; molecular genetic profiling; Egypt.

1. Introduction

Coffee is one of the world's most widely traded agricultural commodities (ICO, 2024) and a daily necessity for millions of people worldwide, forming an integral part of social habits, productivity, and lifestyle in many cultures. Two species dominate commercial production, *Coffea arabica*, prized for its superior cup quality, and *Coffea canephora* (Robusta), valued for its higher yield, greater tolerance to biotic and abiotic stresses, and higher caffeine content (DaMatta & Ramalho, 2006, Mushtaq *et al.*, 2020). Arabica coffee is mainly produced in countries such as Colombia and Ethiopia (FAO, 2024), whereas global Robusta production is largely dominated by Vietnam, Indonesia, and Uganda (ICO, 2024). Robusta is widely cultivated in low- to mid-altitude tropical regions and supplies a large

proportion of the global coffee market, particularly for instant coffee and espresso blends, due to its characteristic body and soluble solids (Borem, 2019; Wintgens, 2012).

Robusta coffee is also characterized by distinct physical and chemical attributes that contribute to its technological and commercial importance. Studies conducted in Southeast Asia and East Africa have demonstrated that Robusta beans generally exhibit higher bean weight, greater hardness, and higher extractability compared to Arabica, making them suitable for industrial coffee processing (Tran *et al.*, 2022; Walyaro *et al.*, 2023). Chemically, Robusta beans contain significantly higher caffeine levels (2.2–3.0%) and moderate chlorogenic acid contents, although these values vary depending on altitude, genotype, soil fertility, and post-harvest treatments (Marques *et al.*, 2021; N'Dri *et al.*, 2020). Research from Vietnam and Uganda—the world's leading Robusta producers—has highlighted considerable variability in bean size, moisture content, lipid composition, and CGA profiles, reflecting the strong influence of environmental conditions and agricultural practices on bean quality (Nguyen *et al.*, 2021; Worku & Mehari, 2024). These physicochemical characteristics collectively define the functional properties, sensory performance, and commercial value of Robusta coffee. In addition to physical and chemical quality traits, molecular genetic profiling using DNA-based markers such as RAPD and ISSR has been widely applied in coffee to assess genetic diversity, confirm cultivar identity, and support breeding and conservation programs (Lashermes *et al.*, 1996; Prakash *et al.*, 2005; Silva *et al.*, 2004).

Despite the extensive global research on *Coffea canephora* (Robusta), there is a marked scarcity—and in many cases a complete absence—of studies evaluating the performance and quality attributes of Robusta coffee cultivated under Egyptian conditions. This represents a genuine scientific gap, particularly given that Egypt currently imports 100% of its coffee requirements. National consumption has risen sharply in recent years, with annual use estimated at 70,000–80,000 tons according to CAPMAS (2024). Consequently, coffee has become one of the most economically significant imported agricultural commodities, with import values increasing from 195.86 million USD in 2023 to 297.55 million USD in 2024.

In parallel, the recent unexpected growth and promising performance of Robusta coffee trees cultivated in the Qanater El- Khairia region of Qalyubia Governorate have attracted considerable public and media attention. This phenomenon—potentially linked to evolving climatic conditions—has intensified national interest in exploring the feasibility of local coffee production. However, no scientific studies have yet characterized the physical, chemical, or agronomic traits of these locally grown Robusta trees. This lack of evidence underscores the urgent need to assess the productivity and bean quality of Egyptian-grown Robusta coffee as a foundational step toward developing a nascent domestic coffee industry. The present study aims to evaluate the physical and chemical characteristics of Robusta coffee beans cultivated under Egyptian environmental conditions and to assess their compliance with internationally recognized quality standards. This work seeks to establish a scientific basis to support the potential development of coffee cultivation in Egypt in light of current climatic changes.

2. Materials and Methods

Study Area

The study was carried out during two consecutive seasons, 2023 and 2024, on *Coffea canephora* (Robusta coffee) trees intercropped with avocado trees at the Horticulture Research Institute Station in Qanater El-Khairia, located in Qalyubia Governorate, Egypt. The experimental site is characterized by fertile alluvial soils and proximity to the Nile River branches, providing favorable moisture and nutrient for crop growth (Table, 1).

Soil analysis

Soil physical and chemical analysis of the experimental study as shown in Table (1).

Climatic conditions

Meteorological data for the experimental site during (2023&2024) were obtained from the Climate Change Information Center (CCICREES), Agricultural Research Center (ARC), Egypt. The data presented in Table (2) included monthly maximum and minimum temperatures, mean temperature,

relative humidity, rainfall, and wind speed. The climatic conditions during the study period were characterized by warm to hot summer conditions, with mean temperatures reaching approximately 30–32 °C during July and August, accompanied by low to moderate relative humidity. Rainfall was generally limited throughout most of the year, with relatively higher amounts recorded during the winter months. Wind speed remained within a moderate range during the study period.

Table (1). Soil physical and chemical analysis

Soil properties			
Physical properties:		Chemical properties:	
Sand %	10.5	Organic matter %	2.50
Silt %	49.2	pH	8.35
Clay %	42	EC (ds/m)	0.32
Texture %	loamy	CaCO ₃ %	0.95
Available micro elements (ppm) :			
N %	0.2		
P %	0.002		
K %	0.05		
Fe (ppm)	6.0		
Mn (ppm)	3.0		
Zn (ppm)	1.0		
Cu (ppm)	1.2		

Table (2). Monthly Climate Averages for El-Qanater Research Station (2023–2024)

Month	Temp.max (°C)	Temp.Min (°C)	Mean Temp. (°C)	RH (%)	Rainfall (mm)	Wind Speed (ms ⁻¹)
2023						
January	16.76	5.40	11.08	67.08	33.38	2.50
February	19.48	6.57	13.03	66.60	10.79	2.52
March	21.18	7.03	14.10	59.98	40.32	3.02
April	31.43	13.51	22.47	44.97	0.00	3.20
May	33.65	16.68	25.17	39.75	0.00	3.37
June	37.44	20.94	29.19	42.11	0.00	3.24
July	38.36	21.41	29.88	42.45	1.90	3.02
August	38.45	22.73	30.59	46.09	1.74	3.06
September	36.57	21.27	28.92	49.15	3.94	3.12
October	30.70	17.78	24.24	57.68	5.71	2.72
November	25.62	13.36	19.49	59.84	0.82	2.23
December	23.05	11.17	17.11	63.49	24.92	2.22
2024						
January	20.48	8.27	14.37	68.53	80.59	2.20
February	18.88	6.38	12.63	69.79	10.56	2.38
March	25.65	10.82	18.24	54.11	5.99	2.67
April	29.59	13.35	21.47	45.50	3.10	2.88
May	33.53	16.98	25.26	42.50	0.81	3.43
June	37.66	21.39	29.52	39.59	1.11	3.50
July	40.51	22.74	31.62	40.54	0.00	3.23
August	39.57	23.05	31.31	44.57	0.00	3.21
September	37.82	22.31	30.07	45.29	0.03	2.87
October	31.98	19.40	25.69	58.11	53.06	2.59
November	26.73	14.92	20.82	65.09	5.51	2.36
December	22.52	11.52	17.02	71.69	26.07	2.43

Data obtained from the Climate Change Information Center (CCICREES), Agricultural Research Center, Egypt.

Plant material

The experiment was carried out on uniform, healthy Robusta coffee (*Coffea canephora*) trees older than 20 years. All selected trees were similar in vigor and canopy structure to ensure sampling uniformity.

Vegetative and floral measurements

Data on vegetative and floral traits were collected from three replicates, with three coffee trees per replicate distributed across two rows. The trees within each replicate were randomly selected from the coffee trees established in the study area. The total number of primary branches per tree was counted. Six Shoots were randomly selected from each tree for measurements of shoot length (cm), measured from the base to the apical bud, and the number of fully expanded leaves per shoot. Flowering in the coffee trees occurred mainly during January and February. During the flowering period, the total number of flowers per selected shoot was counted, followed by recording the number of developing fruits to calculate fruit set percentage. Coffee cherries developed approximately 4–7 months after flowering. Ripening was asynchronous, with cherries reaching maturity at different rates within the same field and even on the same tree. At harvest, yield per tree was determined by collecting and weighing all mature coffee cherries.

Physical Traits Assessment

Physical traits of coffee berries and beans were evaluated using randomly selected samples at harvest.

Berry (fruit) measurements

Berry length, width, and berry diameter was measured using a caliper, while External fruit color was visually assessed at the fully ripe stage and recorded based on the predominant color observed on the fruit surface.

Bean (seed) measurements

After removal of the pulp and parchment, the bean length, width, thickness, and weight of 100-bean were measured.

Chemical Analysis

Caffeine and chlorogenic acid contents in coffee beans were determined using High Performance Liquid Chromatography (HPLC) according to the standard methods of the Association of Official Analytical Chemists (AOAC, 2019). Dried green coffee beans were finely ground, and the target compounds were extracted using aqueous methanol. The extracts were filtered through a 0.45 µm membrane filter prior to injection into the HPLC system. Separation was carried out on a C18 column, and detection was performed using a UV detector at suitable wavelengths. Quantification was achieved using external calibration curves prepared from analytical-grade caffeine and chlorogenic acid standards. All analyses were conducted in three replicates, and the results were expressed as percentage on a dry weight basis.

Molecular Genetic profile

1- DNA Isolation

Genomic DNA was isolated from freshly leaves by DNeasy plant mini kit (bio basic). DNA quality was checked by means of absorbance ratios A260/A280 through a UV-spectrophotometer where DNA is pure with a ratio A260/A280 from 1.8-2.0. Moreover, using electrophoresis in 1% agarose gel with ethidume bromied, a qualitative check for DNA samples was done.

2- Polymerase Chain Reaction

Genomic DNA was used as a template for Polymerase Chain Reaction (PCR) amplification using 8 SCoT primers, SCoT primers were designed from consensus sequence derived from the previous studies by Joshi *et al.* (1997); Collard and Mackill, (2009) and Mohamed *et al.*, (2015) and procured from Biobasic Com. All SCoT primers were 18-mer and were from Dataset I which based on highly

expressed genes as described by **Sawant *et al.* (1999)**. For SCoT primers design, the start codon ATG (+1, +2, and +3), 'G' at position +4, 'C' at position +5, and A, C, C and A at positions +7, +8, +9 and +10, respectively, were fixed (5'-----ATGGCTACCA---3').

3- Polymerase Chain Reaction

Amplification reactions for SCoT techniques were performed as described by **Fathi *et al.* (2013)** and **Xiong *et al.* (2011)**, and were carried out in Techni TC-512 Thermal Cycler as follows: One cycle at 94 °C for 4 min followed by 40 cycles of 1 min at 94 °C, 1 min at annealing temperature 57 °C for 2 min at 72 °C, followed by 72° C for 10 min, the reaction product was finally stored at 4 °C.

4- Gel Electrophoresis

Amplified products were loaded and separated on a 1.5% agarose gel with ethidium bromide and 100 bp to 1kb ladder markers. The run was carried out for about 30 min at 100 V in mini submarine gel BioRad.

5- Gel reading and analysis

DNA banding pattern photos were photographed using Bio-1D Gel Documentation system and were analyzed by GelAnalyzer3 software which scoring clear amplicons as present (1) or absent (0) for each primer and entered in the form of a binary data matrix. From this matrix, DNA-profiles were performed for ISSR and SCoT techniques according to **Adhikari *et al.* (2015)**. According to binary data matrix, Molecular distances MD (Dissimilarity) were calculated by Dice coefficient (**Nei and Li, 1979**) and cluster analysis was performed agglomerative hierarchical clustering (AHC) analysis derived from Unweighted pair-group average UPGMA method using XLSTAT.7 software.

Table (3). List of the used SCoT and ISSR primers

No.	Name	SCoT Primers	No.	Name	ISSR Primers
1	SCoT 3	5` GTG TGT GTG TGT GC 3`	1	UBC-25	5` CAC CAC CAC GC 3`
2	SCoT 45	5` GAGAGAGAGAGACC 3`	2	UBC-26	5` GAGGAGGAGGC 3`
3	SCoT 55	5` GTG TGT GTG TGT TGT CC 3`	3	UBC-33	5` GTGTGTGTGTGTGC 3`
4	SCoT 10	5` GTG TGT GTG TGT TGT CC 3`	4	UBC-40	5` GTGTGTGTGTGTGC 3`
5	SCoT 70	5` GTG TGT GTG TGT TGT CC 3`	5	UBC-50	5` GTGTGTGTGTGTGC 3`

Statistical Analysis

Data obtained from the two growing seasons were subjected to statistical analysis using an independent samples t-test. All measurements were performed in three replicates. Results were expressed as mean $\pm$ standard error (SE), and statistical significance was determined at $p \leq 0.05$. Statistical analyses were carried out using (SPSS) software.

3. Results and Discussion

Vegetative and floral measurements

The vegetative and floral measurements of Robusta coffee trees during the two growing seasons are presented in Table (4) and fig. (1). The number of primary branches per tree ranged from 13.00 to 13.67, while shoot length averaged between 65.33 and 66.00 cm in both seasons. The number of leaves per shoot showed very close values, ranging from 15.33 to 15.67 leaves in both seasons. Flowering and fruiting traits also remained stable, with the number of flowers per shoot ranging from 13.33 to 13.67 and the number of fruits per shoot from 26.33 to 31.67 in both seasons. Yield per tree varied from 3.67 to 5.00 kg across the two seasons. Statistical analysis indicated that these differences were not significant, reflecting stable vegetative growth and reproductive performance over successive seasons.

Table (4). Vegetative and floral traits of “Robusta” coffee trees grown in Qanater El-Khairia, Egypt during the (2023–2024 seasons)

Trait	1 st season	2 nd Season	t-value	P-value	Significance
Number of branches	13.67± 0.88	13.00±1.15	0.329	0.773	Ns
Shoot length(cm)	65.33± 2.03	66.00± 1.53	-0.277	0.807	Ns
Number of leaves	15.33±1.76	15.67± 1.20	-0.152	0.892	Ns
Number of flowers	13.67±0.88	13.33± 0.33	0.378	0.741	Ns
Number of fruits	26.33± 4.67	31.67± 4.41	-0.922	0.453	Ns
Yield (kg)	5.00± 0.58	3.67± 0.33	2.000	0.183	Ns

Values are expressed as mean ± standard error (SE). Differences between the two growing seasons were evaluated using an independent samples t-test at $p \leq 0.05$.

The vegetative and floral traits recorded in the present study are comparable to those reported for Robusta coffee grown in major producing countries. Previous studies conducted in Vietnam and Indonesia indicated that shoot length of Robusta coffee typically ranges from 60 to 80 cm, while the number of leaves per shoot commonly varies between 12 and 20 leaves under shaded or semi-shaded cultivation systems (Nguyen *et al.*, 2021; Rahardjo *et al.*, 2018). Similarly, stable flowering and fruit set have been reported for Robusta plantations in East African regions, where moderate shading contributes to uniform reproductive development (Wintgens, 2009).

The observed stability in vegetative growth and yield across seasons in the present study is consistent with reports highlighting the adaptability of *Coffea canephora* to diverse tropical environments and its tolerance to environmental fluctuations (DaMatta *et al.*, 2019). These findings suggest that Robusta coffee cultivated under Egyptian conditions can achieve vegetative and reproductive performance within the international range reported for leading Robusta-producing regions, particularly when grown under agroforestry or shaded systems.

Physical Traits Assessment

Berry (fruit) measurements

The physical characteristics of coffee fruits, including fruit length, width, and diameter, are presented in Table 5. The results indicated that fruit length averaged (1.43 and 1.60 cm) in both seasons respectively, with no significant difference between seasons ($p > 0.05$). Similarly, fruit width recorded mean values of 1.00 cm and 1.09 cm in the first and second seasons, respectively, while fruit diameter ranged from 1.00 to 1.04 cm, with all differences being statistically non-significant, in both seasons, coffee fruits exhibited a bright red color at full ripeness (Figure 1), which is considered the typical maturity stage for high-quality Robusta coffee.

The absence of significant seasonal variation suggests a high degree of stability in fruit physical traits under the agro-climatic conditions of Qanater El-Khairia. Such stability is considered a desirable characteristic in coffee production, as fruit size uniformity is closely associated with consistent bean development and processing quality.



Fig. (1). Floral and fruiting characteristics of *Coffea canephora* (Robusta) trees grown in Qanater El-Khairia, Egypt

Table (5). Physical characteristics of coffee fruits “Robusta” grown in Qanater El-Khairia, Egypt during the (2023–2024 seasons)

Trait/ (cm)	1 st season	2 nd Season	t-value	P-value	Significance
Fruit length	1.43 ± 0.09	1.60 ± 0.06	−1.147	0.370	Ns
Fruit width	1.00 ± 0.06	1.09 ± 0.06	−1.606	0.249	Ns
Fruit diameter	1.04 ± 0.03	1.00 ± 0.03	1.732	0.225	Ns

Values are expressed as mean ± standard error (SE). Differences between the two growing seasons were evaluated using an independent samples t-test at $p \leq 0.05$.

When compared with international reports on *Coffea canephora*, the recorded fruit dimensions fall within the typical ranges reported for Robusta coffee cultivated in major producing countries. Previous studies have indicated that Robusta coffee fruits commonly exhibit lengths ranging from 1.2 to 1.8 cm and widths between 0.9 and 1.2 cm, depending on genotype and environmental conditions (Tran et al., 2022; Walyaro et al., 2023). Comparable fruit dimensions were also reported for Robusta coffee grown in Vietnam and Côte d'Ivoire, where fruit size has been linked to favorable bean filling and higher market acceptability (Nguyen et al., 2021; N'Dri et al., 2020). Therefore, the physical fruit traits observed in the present study demonstrate that locally cultivated Robusta coffee in Egypt exhibits fruit characteristics comparable to those of internationally recognized Robusta-producing regions. These findings support the potential of Egyptian-grown Robusta coffee to meet global physical quality standards and reinforce its suitability for commercial production.

Bean (seed) measurements

The physical characteristics of coffee seeds are presented in Table (6). Seed length averaged (1.01 and 1.12 cm) in both seasons, respectively, while seed width ranged from 0.95 cm to 1.07 cm in both seasons. Seed diameter showed mean values of 0.76 cm and 0.75 cm in the first and second seasons, respectively. No significant differences were detected between seasons for seed dimensions ($p > 0.05$). In contrast, the 100-seed weight showed a significant increase in the second season (105.33 ± 2.03 g) compared with the first season (101.00 ± 2.08 g) ($p \leq 0.01$). This increase reflects improved seed filling and dry matter accumulation, which are key indicators of bean physical quality.

Table (6). Physical characteristics of coffee seeds (Beans) “Robusta” grown in Qanater El-Khairia, Egypt during the (2023–2024 seasons)

Trait	1 st season	2 nd Season	t-value	P-value	Significance
Seed length (cm)	1.01 $\pm$ 0.02	1.12 $\pm$ 0.05	−1.976	0.186	Ns
Seed width(cm)	0.95 $\pm$ 0.05	1.07 $\pm$ 0.04	−1.585	0.253	Ns
Seed diameter(cm)	0.76 $\pm$ 0.04	0.75 $\pm$ 0.03	0.154	0.891	Ns
100-seed weight(gm)	101.00 $\pm$ 2.08	105.33 $\pm$ 2.03	−13.000	0.005	**
Color	Greenish brown				

Values are expressed as mean $\pm$ standard error (SE). Differences between the two growing seasons were evaluated using an independent samples t-test at $p \leq 0.05$.

The absence of significant seasonal variation in seed length, width, and diameter indicates a relative production stability of the studied *Coffea canephora* genotype, as seed size traits are known to be less influenced by seasonal fluctuations compared with yield-related parameters (Walyaro et al., 2023; Nguyen et al., 2021). Similar ranges of seed dimensions have been reported for Robusta coffee cultivated under different agro-ecological conditions in Vietnam and Uganda (Tran et al., 2022; Walyaro et al., 2023). The significant increase in 100-seed weight observed during the second season reflects improved seed filling and dry matter accumulation, which are strongly associated with favorable environmental conditions during the bean development stage (Borem, 2019; Worku & Mehari, 2024). Seed weight is considered one of the most reliable physical quality indicators in Robusta coffee, as it directly influences processing efficiency and commercial grading (ICO, 2024; Mushtaq et al., 2020).

Overall, the obtained values for seed physical traits fall within internationally accepted standards for *Coffea canephora*, supporting the competitive potential of Egyptian-grown Robusta coffee in global markets (FAO, 2024; Borem, 2019).

Chemical traits

Data presented in Table 6 showed that the caffeine content in green coffee beans averaged 2.87% in the first season and 2.97% in the second season. These values are consistent with the characteristic

biochemical profile of *Coffea Canephora* (Robusta), which is generally characterized by higher caffeine content than *Coffea arabica*. Previous studies have reported caffeine contents in Robusta beans ranging from 2.0 to 3.5%, depending on genotype and growing environment (Farah and Donangelo, 2006; Ky et al., 2001). Similar caffeine concentrations have been documented in Robusta coffee cultivated in major producing countries such as Vietnam and Indonesia, confirming that the values observed under Egyptian conditions fall within the internationally accepted range for high-quality Robusta beans.

Table (7). Caffeine and chlorogenic acid contents (%) in green coffee beans of *Coffea canephora* (Robusta) during two successive (2023–2024 seasons)

Trait	1 st season	2 nd Season	t-value	P-value	Significance
Caffeine (%)	2.87 ± 0.19	2.97 ± 0.12	−0.577	0.622	Ns
Chlorogenic acid (%)	5.40 ± 0.87	6.27 ± 0.39	−1.267	0.332	Ns

Values are expressed as mean ± standard error (SE). Differences between the two growing seasons were evaluated using an independent samples t-test at $p \leq 0.05$

Chlorogenic acid content in the present study (Table, 6) ranged from 5.40% in the first season to 6.27% in the second season, which agrees well with earlier reports indicating that Robusta coffee typically contains higher chlorogenic acid levels than Arabica, usually ranging between 4.0 and 8.0% (Clifford, 2000; Farah et al., 2012). Comparable chlorogenic acid contents have been reported for Robusta beans grown in Indonesia and Uganda, where environmental conditions and genetic background strongly influence phenolic accumulation.

The absence of significant seasonal variation in both caffeine and chlorogenic acid contents suggests a relative stability of these chemical constituents under the shaded cultivation system used in this study. This stability may indicate that Robusta coffee grown under Egyptian agro-climatic conditions, particularly under avocado shade, is capable of producing beans with chemical quality attributes comparable to those of leading Robusta-producing regions worldwide.

Molecular Genetic profile

Table (8). SCoT-PCR markers

SCoT

SCoT

Band No	M.W bp					
		S3	S4 5	S5 5	S1 0	S7 0
1	530	-	-	-	1	-
2	480	1	-	-	1	-
3	275	1	1	1	1	1
4	215	-	1	-	-	1
Total		2	2	1	3	2

Fig. (2). SCoT-PCR markers

Data of the amplified fragments using five SCoT primers for (Robusta) Coffee plant succeeded in amplifying DNA fragments (Table 7. and Figure 2.). Primer SCoT 3 resulted in two bands with molecular sizes from 480 and 275bp and Primer SCoT 45 resulted in two bands with molecular sizes 275 and 215 bp. While, Primer SCoT 55 indicated the amplification of one band with molecular size range 275 bp and Primer SCoT 10 indicated the amplification of three bands with molecular weight size 530, 480 and 275 bp respectively. On the other hand, primer SCoT S70 resulted in two DNA fragments with molecular weight in 275 and 215 bp.

Table (9). ISSR- PCR markers

ISSR

ISSR

Band No	M.W bp					
		U25	U26	U33	U40	U50
1	680	-	1	1	-	1
2	635	-	-	-	1	-
3	540	1	-	-	1	-
4	430	1	-	-	-	-
5	370	-	-	1	-	1
6	285	-	1	1	1	1
7	200	-	1	-	-	1
Total		2	3	3	3	4

Fig. (3) ISSR- PCR markers

Inter Simple Sequence Repeats (ISSR)

Data of the amplified fragments using those five ISSR primers for the (Robusta) Coffee plant in amplifying DNA fragments (Table 9 and Figure 3). Primer UBC-25 resulted in two bands with molecular sizes 540 and 480bp and Primer UBC-26 resulted in three bands with molecular sizes 680, 285 and 200 bp. While, Primer UBC-33 indicated the amplification of three bands with molecular size 680, 370 and 285 bp and also Primer UBC-44 indicated the amplification of three bands with molecular weight size 635, 540 and 285bp. On the other hand, primer UBC-50 resulted in four DNA fragments with molecular weight 680, 370, 285 and 200bp.

4. Conclusion

This study evaluated the productivity and quality attributes of *Coffea canephora* (Robusta) cultivated under avocado shade and the agro-climatic conditions of Qanater El-Khairia, Egypt. The results showed relatively stable vegetative growth, fruit characteristics, and chemical composition across the two seasons. The study also provided a preliminary characterization of the quality of Robusta coffee grown under Egyptian conditions by comparing its fruit and bean characteristics with those reported from major Robusta coffee-producing regions worldwide. The results showed promising quality attributes, particularly the caffeine content, supporting the potential for

further development of Robusta coffee cultivation in Egypt. In addition, molecular characterization using SCoT and ISSR markers provided a molecular profile of the studied Robusta coffee material. Overall, these findings provide strong evidence for the feasibility of developing sustainable Robusta coffee production in Egypt under the prevailing agro-climatic conditions. Future studies are recommended to expand cultivation trials across different regions and to further assess post-harvest processing and sensory quality to support commercial production.

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