



CYTOLOGICAL CHARACTERIZATION OF TOMATO (*SOLANUM LYCOPERSICUM* L.) GERMPLASM

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ABSTRACT

Germplasm diversity of any crop plays a significant role in the establishment of a successful breeding programme. In this study, five tomato germplasm, namely Roma Savannah, Tima, UTC, *Dan Zaria* and *Tagino* were collected from the Nasarawa State College of Agriculture, Lafia were evaluated for their cytological characterization to determine the germplasm cytological karyotyping parameters. The number of chromosomes in all lines was $2n = 24$, except for *Tagino*, in which the number was $2n = 26$, whereas chromosome sizes were small, ranging from 322.09 to 461.17 μ m. The Roma Savannah cultivar was a symmetrical cultivar (primitive), having the highest total form percentage (TF%) and symmetry index (Syi) values and the minimum karyotype asymmetry index (ASK) value, whereas *Dan Zaria* was asymmetrical (advanced) which makes it a superior germplasm among the other five evaluated. On the whole, the application of cytological techniques could be considered as a means to provide suitable parameters for studying the evolution of the genetic divergence between the studied tomato lines which can aid in preserving genetic resources in gene banks and improving new cultivars in breeding systems.

Keywords: Chromosomes, Diversity, Germplasm, Gene banks, Tomato.

INTRODUCTION

The tomato (*Solanum lycopersicum* L.) fruit is quite popular and consumed in a variety of dishes across the globe. Despite the popularity, there is scarcity of information regarding its seed cytology that distinguishes varieties and often difficult to identify the germplasm with the best set of chromosomal characters. More so, preserving the genetic resources in gene banks and improving new cultivars in breeding systems. The tomato plant, *Solanum lycopersicum* L. which are of two types; The determinate (temperate and tropical annuals) and the indeterminate (tropical perennials) is a dicotyledonous, branched, decumbent herb of the order; *Solanales* grown worldwide in greenhouses, net houses and outdoor fields (Peet, 2009). The species originated from South America, spread around the world and was introduced to Africa by the Portuguese about 5 centuries ago (RMRDC, 2017). Being the 14th largest producer of tomato in the world, Nigeria has been cultivating tomato majorly in the northern part of the country due to its less rainfall and abundance of rich loamy soil (FAOSTAT, 2014). Tomato is a major vegetable crop that has achieved tremendous popularity in the world with about 4.7 million hectares planted to tomato annually accounting for 14% of global vegetable production although it is botanically classified as a fruit but considered a vegetable for culinary purposes (FAO, 2012). Tomato breeding strategy involves generating various germplasm and selection of superior genotypes for utilizing them in hybridization programs to develop a superior variety or hybrid (Rajasekhar, *et al.*, 2013). To achieve this, it is necessary to collect germplasm from indigenous and exotic sources for proper and systematic evaluation to understand and estimate the extent of variability, heritability and character associated with yield components and quality traits. Knowledge of germplasm diversity of any crop plays a significant role in the establishment of a successful breeding programme of that crop (Dasikwo *et al.*, 2020). In



Nigeria, tomato is regarded as the most important vegetable after onions and pepper (Ebimieowei and Ebideseghabofa, 2013). The fruit is highly nutritious and contains high levels of lycopene, a powerful antioxidant associated with lower risk of cancers, heart and age-related diseases, (Achoja and Okoh, 2014). It is an important condiment in most diets and a very cheap source of vitamins. It also contains a large quantity of water (95%), calcium and Niacin all of which are of great importance in the metabolic activities of man. Tomato is a good source of vitamins A, C and E and minerals that are very good for body and protect the body against diseases (Olayemi *et al.*, 2010) mainly due to the content of antioxidants including carotenes, ascorbic acid and phenolic compounds (Ayandiji and Adeniyi, 2011). It is an important crop that has great agricultural value that is still being discovered. It is also an acknowledged model species for research on fruit development and metabolite accumulation. With the rising need to increase the availability of fresh tomato to meet up with the high demand for this commodity particularly during hot season, evaluating the diversity of tomato germplasm and providing information on varieties that could be used to provide lasting solutions to the constraints of tomato production in Nigeria will go a long way in bridging the gap between the demand and supply thereby boosting the economy and providing employment to people that wish to venture into tomato production. This study is also going to be of great importance to current and future agronomists and genetic improvement specialists. Moreover, knowledge of the relationship among plant cytological characters is useful while formulating selection scheme with target in preserving genetic resources in gene bank to improve yield in breeding systems.

MATERIALS AND METHODS

The experimental material comprised of 5 tomato germplasm varieties collected from the college of Agriculture, Lafia, Nasarawa State. The varieties and their sources are explained as thus.

Table 1: Sources of Germplasm Varieties

S/N	Variety	Local Sources
1.	Roma Savannah	Jos, Plateau State
2.	Tima	Jos, Plateau State
3.	UTC	Jos, Plateau State
4.	<i>Dan Zaria</i>	Zaria, Kaduna State
5.	<i>Tagino</i>	Zaria, Kaduna State

Cytological Studies of the Tomato Germplasm

About 10 seeds from each tomato line were germinated at room temperature in Petri dishes. Root tips were collected and treated with 0.04 8-hydroxyl quinolone for 2 h. Then, root tips were fixed in a 3:1 (v/v) ratio of alcohol: glacial acetic acid for 24 h. Root tips were hydrolyzed in 1.0 N HCl for 20 min at room temperature. Root tips were stained using 2% aceto-orcein stain. At least 10 metaphase cells were counted using an Olympus CX40 microscope and photographed using a digital camera at X = 100. Karyotype analyses were carried out using KaryoType software, and ideograms were drawn. Different karyotype parameters were measured and mentioned.

RESULTS AND DISCUSSION

The chromosome number of all tomato lines was $2n = 24$, except for the Tangino germplasm, in which the number was $2n = 26$, as shown in Figure 1. Ideograms of haploid



chromosome numbers for the five studied germplasms are illustrated in Figure 1. Different karyotype parameters are presented in Table 2. Karyotype formulas nearly metacentric (nm) and metacentric (m) were recorded in all five germplasm, whereas karyotype formula nearly submetacentric (ns) was found in Tima, *Dan Zaria* and Tangino germplasms. The highest values for the coefficient of variation of centromeric index (CVCI), mean centromeric asymmetry (MCA), the Karyotype asymmetry index (ASK%), intrachromosomal asymmetry index (A1), interchromosomal asymmetry index (A2), and asymmetry index (AI) parameters were recorded in the *Dan Zaria* germplasm, being 14.76, 16.75, 58.05%, 0.27, 0.17, and 2.56, respectively. In contrast, the lowest values of these parameters were present in the Roma Savannah germplasm, at 6.19, 8.87, 54.44%, 0.16, 0.09, and 1.15, respectively. On the other hand, the total form percentage (TF %) and symmetry index (Syi) were found to have the highest values, at 45.56% and 83.69%, respectively, in the Roma Savannah germplasm. TF% and Syi had the lowest values in the *Dan Zaria* germplasm, at 41.95% and 72.25%, respectively, as shown in Table 2. The chromosome number of studied cultivars was $2n = 24$, except for the Tangino germplasm in which the number was $2n = 26$, which is in agreement with the results found by Banks 1984 and Badr *et al.*, 1997 who recorded the basic number of Solanaceae as $x = 7, 9, 12, 14$. The difference in chromosome number or chromosome formula was associated with morphological variation, as Tangino varied from the other germplasm in several characteristics, such as leaves, plant height, and leaf area. The main karyotype formulas of studied tomato cultivars were nearly metacentric nm, and nearly submetacentric ns, which was in accordance with the results reported by Moscone *et al.* (2007) who reported that the majority of chromosomes in Solanaceae are m or sm. The evolution of a plant associated with variation of karyotype parameters, is estimated using different indices of symmetry. Rec and Syi indices vary from 0 to 100 (Fonsêca *et al.*, 2013), and TF % vary from 0 to 50 (Zuo *et al.*, 2011). According to the highest TF and Syi value and the lowest ASK value, Roma Savannah was the most symmetrical, and *Dan Zaria* was the most asymmetrical. According to A1 and A, the Roma Savannah germplasm was the most primitive, and *Dan Zaria* was the most advanced. A higher value of A1 points to a higher level of asymmetry (Murat *et al.*, 2015).



Table 2: Different Karyotype Parameters for five tomato germplasm

Germplasm	Chromosome Number (2n)	THL (µm)	CVCI	CVCL	MCA	ASK%	TF%	Syi Index	Rec Index	A1	A2	A	DI	AI	Stebb	KF
Roma savannah	24	375.22	6.19	18.52	8.87	54.44%	45.56%	83.69%	65.74%	0.16	0.19	0.09	8.43	1.15	1B	18 nm + 6 m
Tima	24	393.11	10.37	16.28	13.51	56.96%	43.04%	75.55%	72.92%	0.23	0.16	0.14	6.85	1.69	1A	6 nsm(-)+14nm+4 m
UTC	24	322.09	6.38	22.22	13.16	56.48%	43.52%	77.04%	64.99%	0.23	0.22	0.13	10.04	1.42	1B	22 nm + 2 m
Dan Zaria	24	451.43	14.76	17.31	16.75	58.05%	41.95%	72.25%	69.59%	0.27	0.17	0.17	7.56	2.56	2 B	4 nsm(-)+18 nm+2 m
Tagino	26	461.17	9.77	22.49	12.81	56.54%	43.46%	76.88%	63.61%	0.22	0.22	0.13	9.79	2.20	2 B	2 nsm(-)+18nm+6nm

THL: Total haploid chromosome length; CVCI: Coefficient of variation of centromeric index; CVCL: Coefficient of variation of chromosome length; MCA: Mean centromeric asymmetry; ASK: Karyotype asymmetry index; TF%: Total form percentage; Syi: Symmetry index; Rec index: Resemblance between chromosomes; A1: Intrachromosomal asymmetry index; A2: Interchromosomal asymmetry index; AI: Asymmetry index; Stebb: Stebbins classification; KF: Karyotype formula

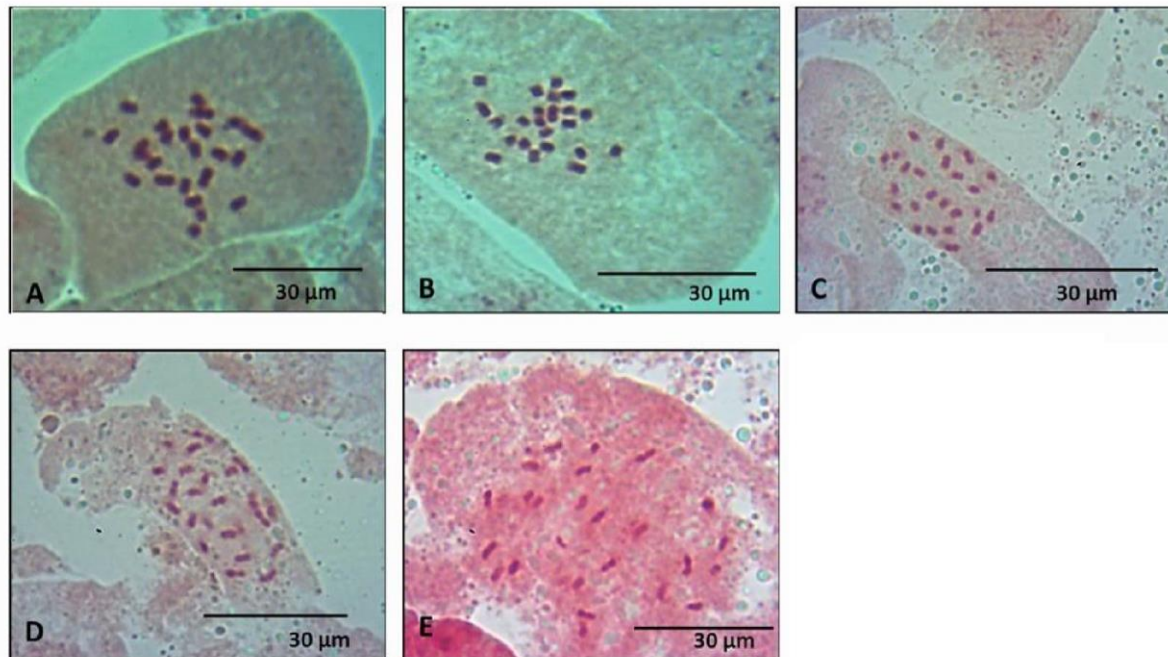


Figure 1: Somatic chromosome number of five lines of tomato (A) Roma Savannah: $2n = 24$, (B) Tima: $2n = 24$, (C) UTC: $2n = 24$, (D) Dan Zaria: $2n = 24$, (E) Tangino: $2n = 26$, $X = 1000$. Scale bar = $30 \mu\text{m}$.

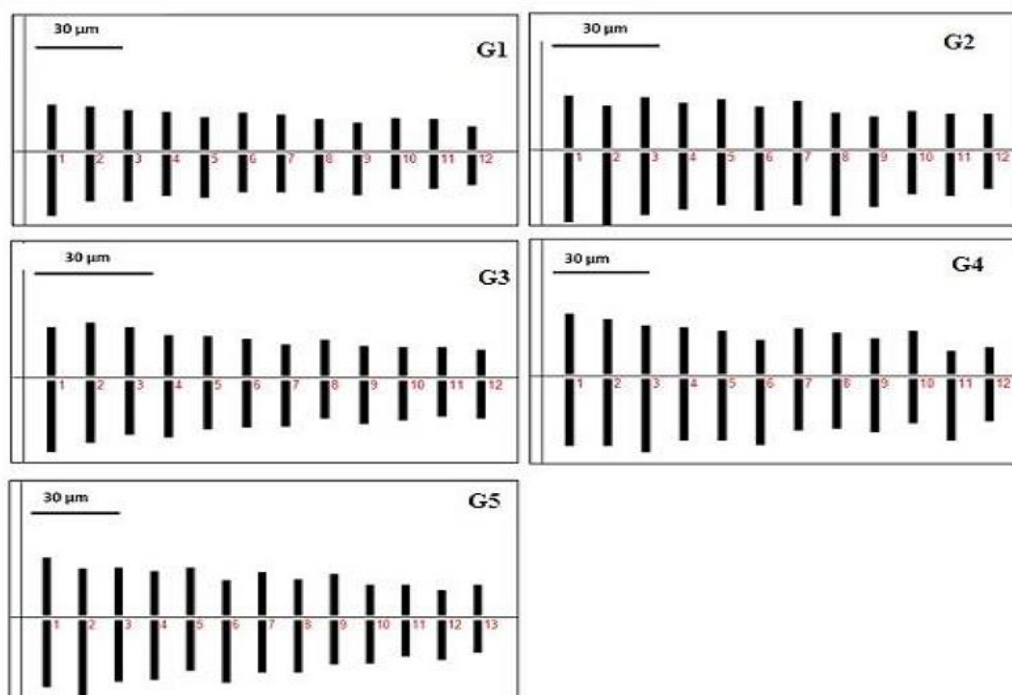


Figure 2: Ideogram of five germplasm of tomato. Scale bar = $30 \mu\text{m}$.

CONCLUSION AND RECOMMENDATIONS

The number of chromosomes in all lines was $2n = 24$, except for Tagino, in which the number was $2n = 26$, whereas chromosome sizes were small, ranging from 322.09 to 461.17 μm . The Roma Savannah cultivar was a symmetrical cultivar (primitive), having the highest



total form percentage (TF%) and symmetry index (Syi) values and the minimum karyotype asymmetry index (ASK) value, whereas Dan Zaria was asymmetrical (advanced) which makes it a superior germplasm among the other five evaluated. On the whole, the application of cytological techniques could be considered as a means to provide suitable parameters for studying the evolution of the genetic divergence between the studied tomato lines which can aid in preserving genetic resources in gene banks and improving new cultivars in breeding systems.

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