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EVALUATION FOR DIVERSITY IN GROWTH AND YIELD OF TOMATO (*SOLANUM LYCOPERSICUM* L.) GERMPLASM

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ABSTRACT
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 characters that distinguishes varieties and often difficult to identify the germplasm with the best set of phenotypic characters from fruits available in the local market. 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 at morphological levels in a Randomized Complete Block Design (RCBD) with five replications at the Plant Science and Biotechnology Research Garden, Nasarawa State University, Keffi. The mean performance of five tomato varieties studied yield (fruits) and other agronomic traits were significantly different (P >0.05). The average results clarified that the Dan Zaria lines recorded the highest flowering values, as well as some fruit and vegetative growth traits. Furthermore, Tima, Tagino and UTC had the minimum number of fruits/plants, number of leaves, sub branches and flowers. In conclusion, the application for morphological techniques could be considered to provide suitable parameters for studying the evolution of the genetic divergence between the studied tomato lines.

Keywords: Diversity, Evaluation, Growth, Tomato, Yield.

INTRODUCTION
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 (Mauny, 1970). 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 fruit is consumed in a variety of ways ranging from eaten raw to being used as an ingredient in many dishes, sauces, salads and drinks (Ahmed *et al*., 2012). Tomato has become an important cash and industrial crop in many parts of the world not only because of its economic importance but also its nutritional value to human diet and subsequent importance to human health (Ayandiji *et al*., 2011). It is rich in vitamins, minerals, sugars, essential amino acids, iron, dietary fibers and the carotenoid, lycopene which has been linked to many health benefits including reduced risk of cardiovascular diseases and cancer (Freeman & Reimers, 2010). Due to its broad use for food consumption and adaptation to many environmental conditions and different crop systems, tomato experienced an important phenotypic diversification (Babalola *et al*., 2010). Tomato is currently a popular fruit vegetable in Nigeria. However, its production in Nigeria is low (An Average yield per hectare of 7 Metric Tons, MT) compared with those of the temperate zones due to differences in crop environmental conditions, lack of high yielding varieties and cultural practices applied to the crop on the field. Only 1% of Nigerian farmers plant their tomatoes using hybrid seeds and seedlings (Ijewere, 2017). Moreover, there is need to have information on varieties that best suit a certain environment as the demand for improved varieties increases yearly and the delivered varieties are not stable over all environments. Without information on the diversity of tomato varieties available in certain locations in Nigeria, it is difficult to establish a breeding program. 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 of great importance to current and future agronomists and genetic improvement specialists. Moreover, knowledge of the relationship among plant characters and yield is useful while formulating selection scheme with target to improve yield. Therefor the aim of this study is to evaluate the genetic diversity in five tomato lines for yield and growth.

MATERIALS AND METHODS

Description of Experimental Site

The study was carried out at the Botanical Garden of the Department of Plant Science and Biotechnology, Nasarawa State University, Keffi. Keffi, in North Central Nigeria is geographically situated on the coordinates; Latitude 8˚51’36.50”N and Longitude 7˚50’2.01”E with a temperature range that is between 25˚C- 31˚C and about 602mm annual precipitation (Sufiyan, 2020).

Experimental Design

The study was carried out from September to December 2019. The experiment was arranged in a Randomized Complete Block Design (RCBD) with five replications. Each block consisted of 5 beds with a plant of each variety in each bed and an overall total of 25 beds. Seedlings were raised for Four weeks in different colored plastic bowls for easy identification before transplanting to the experimental site. Row-to-row spacing of 60cm and plant-to-plant spacing of 50cm was maintained in each block. The rain was used as the major source of water but manual irrigation was applied after the rains stopped in late November. The plants were watered twice daily. Measurement of plant height was taken in centimeters because the plant of study does not grow to exceed centimeter. The experimental material comprised of 5 tomato germplasm varieties collected from the college of Agriculture, Lafia, Nasarawa State.

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.	Dan Zaria	Zaria, Kaduna State
5.	Tagino	Zaria, Kaduna State

Data Collection

The following data were collected to meet the aim and objective of the study from 29th September, 2019 to 15th December, 2019.

Growth and Yield Determination

Seedlings were transplanted to experimental site four weeks after sowing the germplasm varieties in plastic bowls. Transplanting was done by hand and planting depth of 5cm was maintained. Data was collected from experimental material weekly from the day of transplanting to the day of last harvest (three months). Experimental data was observed and collected based on 2 parameters which are:

i. Growth parameters:
   a) Germination percentage.
   b) Plant height.
   c) Number of branches per plant.
   d) Number of leaves per plant.
   e) Number of sub-branches per plant.
   f) Days to Flowering
   g) Days to 50% flowering

ii. Yield parameters:
   a. Number of fruits/plants.
   b. Weight of fruits/plant.
   c. Number of fruits/experimental unit.

Data for yield parameters were collected from week 12 after transplanting. Mature tomato fruits harvested were counted and weighed to collect data for yield parameters.
All fruits collected were placed back in the plastic bowl each seedling variety was raised to avoid mixing up of data. Fruits were weighed in grams using a digital scale.

Statistical Analysis

All data were subjected to Analysis of Variance which was used to evaluate the statistical significance of variability and divergence among experimental data collected from the varieties. Means were separated using Fishers unprotected testing least significant differences at 5% level when ANOVA showed significant (P<0.05) difference among treatments.

RESULTS AND DISCUSSION

The results for the evaluation for diversity in growth, yield of Tomato (*Solanum lycopersicum* L.) Germplasm are presented in the tables below.

Analysis of Variance for Yield and Growth Parameters

The mean squares from analysis of variance of five tomato varieties growth parameters are presented in Tables 2, 3, 4 and 5 respectively. The results showed a significant difference (P<0.05) for plant height in days to transplanting, 1 week after transplanting (WAT), 2 WAT, 4 WAT, 5 WAT, and 9 WAT, respectively, and a significance difference (P<0.01) was recorded for blocks at 5 WAT, 6 WAT, 8 WAT and 10 WAT (Table 2). A significant difference (P<0.01) was also recorded for number of leaves at days to transplanting, 1 WAT, 5 WAT, 6 WAT, 7 WAT, and 8 WAT respectively and a highly significant difference (P<0.01) was recorded for blocks at 1WAT and 7 WAT respectively (Table 3). The result showed highly significant (P<0.01) differences among the varieties for number of branches at day of Transplanting (DT), 1 WAT, 4 WAT, 7 WAT, and 8 WAT. At 7 WAT and 8 WAT, and a highly significance difference was observed for blocks at 2 WAT and 7 WAT respectively. A highly significance difference (P<0.01) was recorded for the number of sub branches, respectively, with a significance difference observed for blocks at 7 WAT and 8 WAT respectively. At 3 WAT and 4 WAT respectively, a highly significance difference (P<0.01) was seen for days to 50% flowering and blocks respectively (Table 4). A significance difference (P<0.01) was showed on yield (fruits) at 9 WAT, 10 WAT and 11 WAT with a significant difference on blocks at 9 WAT and 11 WAT respectively. The result of flowers showed a significance difference (P<0.01) on the varieties and blocks at 9 WAT and 10 WAT respectively. The results of the weight showed a highly significant difference (P<0.01) on varieties and blocks at 12WAT and 13WAT, respectively. These indicate the heterogeneity in the field (Table 5).

Mean Performance of the Five Tomato Varieties

The mean performance of five tomato varieties studied yield (fruits) and other agronomic traits shows that, Plant height had a progressive increase in weeks after transplanting with lowest mean of 8.86 cm recorded in 1 WAT and the highest mean of 77.79cm recorded in 10WAT. The overall tallest plant was recorded in 9WAT with a mean of 74.07cm on Dan Zaria variety. This agrees with Jones, 2013 who reported that there are five growth stages of tomatoes and the exact days within each stage depends on the varieties. The number of leaves recorded a progressive increase in weeks after transplanting with the lowest mean of 10.36 on DT and the highest mean recorded was 133.56 at 8 WAT. At 8 WAT, Tima variety recorded the lowest number of leaves 96.00 and Dan Zaria recorded the highest number of leaves of 200.40. The number of branches recorded a lowest mean on DT at 4.01 and a highest mean of 13.48. At 8WAT, Tangino variety recorded lowest number of branches of 10.60 and Dan Zaria Variety recorded the highest number of leaves of 17.60. The number of sub-branches recorded a lower number at 7WAT with a mean of 5.59cm and at 8WAT; the highest mean was recorded of 9.21cm. Tangino variety recorded the lowest number of sub-branches (6.4) and variety Dan Zaria recorded the highest number of sub-branches (17.87) all at 8WAT. The number of flowers had a mean that ranged from 3.87 at 11WAT and 7.92 at 10 WAT. At 9 WAT, the highest number of flowers was recorded (9.29) on variety Dan Zaria while at 11WAT recorded the lowest number of flowers (3.80) on Roma Savanna variety and Tangino variety respectively. The yield (fruits) had a mean range from 2.68 at 9 WAT to 4.73 at 10 WAT. The variety with the lowest number of fruits was recorded at 11WAT (3.47) which seen on UTC variety and the variety with the highest fruits was recorded on Dan Zaria variety (12.60) at 11WAT. This is in line with Mahbubar *et al.* (2018) who reported that "Characterization consists of recording those characters which are highly heritable, can easily be distinguished by the naked eye and are expressed in all environments".

The weight of the varieties used had a mean that range from 43.44g at 13 WAT to 45.33g at 12 WAT. The variety with the lowest fruit weight was recorded on Dan Zaria variety (26.51g) and the highest weight was recorded for Tima variety (54.57g) at 13WAT, respectively. This is in accordance with Ogwu *et al.* (2017), who reported that "aside from natural diversity of tomato germplasm, breeding programs have led to greater diversity in fruit size, colour and growth type which concluded that the key to the preference of tomato cultivars is in the variability of their phenotype especially fruit shape, size, quality, plant length, plant size and growth pattern." Blay *et al*. (2011) also reported that a high variability was detected in tomato plant at flowering, fruit set and number of fruits per plant, fruit weight and yield. The results of this study also revealed a wide range of diversity in our collection for most of the evaluated traits, mainly related to vegetative, fruit, and yield and its components. Estimating genetic variation by assessing phenotypic characteristics is considered very important in plant breeding, especially in producing new genotypes with higher productivity, quality, and broader adaptation (Latif et *al*., 2011; Elsayed *et al*., 2015).

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Table 2: Mean Performance for Plant Height in Weeks

Variety	DT PHT	1WAT PHT	2WAT PHT	3WAT PHT	4WAT PHT	5WAT PHT	6WAT PHT	7WAT PHT	8WAT PHT	9WAT PHT	10WAT PHT
A	9.26	11.11	13.88	15.99	18.57	25.98	48.05	56.25	64.26	75.63	78.58
B	8.24	9.53	11.62	15.33	19.63	28.74	54.69	59.33	73.17	76.97	78.65
C	8.75	11.07	13.92	15.25	16.78	24.38	44.41	53.25	67.43	65.62	75.69
D	9.3	10.86	13.54	15.21	16.99	23.22	52.72	54.43	71.89	79.11	77.01
E	8.75	11.19	13.32	15.17	16.96	27.02	55.47	54.60	70.45	73.01	79.00
Mean	8.86	10.75	13.26	15.39	17.79	25.87	51.07	55.57	69.44	74.07	77.79
CV	6.54	10.12	7.12	9.38	11.61	7.89	40.72	20.04	14.73	12.16	10.89
LSD	0.42	0.79	0.69	1.05	1.51	1.49	15.17	8.12	7.46	6.57	6.18

WAT= weeks after transplanting, DT=days to transplanting and PHT=plant height

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Table 3: Mean performance for number of leaves

Variety	DT NL	1WAT NL	2WAT NL	3WAT NL	4WAT NL	5WAT NL	6WAT NL	7WAT NL	8WAT NL
A	10.13	12.80	11.60	11.87	24.07	41.80	77.80	119.80	146.80
B	7.80	10.80	11.60	11.87	25.87	42.73	64.07	98.40	111.20
C	11.47	14.20	12.00	11.73	25.73	38.40	71.27	81.40	96.00
D	12.53	16.80	12.40	11.87	33.20	43.07	99.53	156.20	209.40
E	10.00	12.80	12.00	11.20	20.20	40.73	69.07	95.00	104.40
Mean	10.39	13.48	11.92	11.71	25.81	41.35	76.35	110.16	133.56
CV	21.72	18.80	12.07	13.84	20.50	29.15	36.69	37.77	52.68
LSD	1.65	1.85	1.05	1.18	3.86	8.79	20.43	30.36	51.32

WAT= weeks after transplanting, DT=days to transplanting and NL=number of leaves

Table 4: Mean performance for number of branches and number of sub branches

	DT	1WAT	2WAT	3WAT	4WAT	5WAT	6WAT	7WAT		8WAT	
Variety	**NB**	**NB**	**NB**	**NB**	**NB**	**NB**	**NB**	**NB**	**NSB**	**NB**	**NSB**
A	4.07	4.47	5.6	7.67	4.73	7.27	10.47	11.2	7	14.87	10.6
B	3.2	3.67	6.4	6.73	5.07	7.07	10.6	11.67	3.33	13.07	6.4
C	4.4	4.87	6	6.27	5	6.6	8.47	9.93	2.27	11.27	7.87
D	4.47	5.07	6.2	6.6	5.93	7.4	11.73	14.67	12	17.6	14.8
E	3.93	4.33	6.2	7	5	7.47	8.8	10.47	3.33	10.6	6.4
Mean	4.01	4.48	6.08	6.85	5.15	7.16	10.01	11.59	5.59	13.48	9.21
CV	16.65	18.49	14.49	19.83	14.12	19.93	38.85	27.13	89.35	33.69	64.47
LSD	0.49	0.6	0.64	0.99	0.53	1.04	2.84	2.29	3.64	3.31	4.33

WAT= weeks after transplanting, DT=days to transplanting, NB=number of branches and NSB=number of sub-branches

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Table 5: Mean performance for yield, number of flowers and weight

Variety	**9WAT**		**10WAT**		**11WAT**		**12WAT**		**13WAT**	
	FL	**YD**	**FL**	**YD**	**FL**	**YD**	**YD**	**WGT**	**YD**	**WGT**
A	5.80	3.13	7.60	4.87	3.27	4.33	3.73	42.39	5.13	48.81
B	8.07	1.93	8.73	2.93	3.33	3.60	4.00	52.76	3.93	54.57
C	6.87	1.67	6.40	4.20	4.07	3.47	4.33	44.40	4.33	41.75
D	9.27	4.20	9.00	8.13	4.47	12.60	4.07	37.31	5.07	26.51
E	5.80	2.47	7.87	3.53	4.20	3.80	4.80	49.79	4.73	45.57
Mean	7.16	2.68	7.92	4.73	3.87	5.56	4.19	45.33	4.64	43.44
CV	46.17	73.90	30.95	61.77	51.51	29.88	36.17	28.03	27.57	24.33
LSD	2.41	1.44	1.79	2.13	1.45	1.21	1.10	9.27	0.93	7.71

WAT= weeks after transplanting, FL=number of flowers, YD=yield (fruit), and WGT=weight

CONCLUSION AND RECOMMENDATIONS

The germplasm evaluated were significantly different. Efforts for tomato amelioration through traditional breeding based on helpful morphological traits are incapable of achieving considerable success. These findings reinforce the utility of morphological parameters in sorting and investigating relationships between the studied tomato germplasm. Among all the germplasm evaluated, Dan Zaria recorded the highest values for morphological traits, vegetative growth and fruiting. However, it recorded the lowest value in terms of fruit weight with Tima Variety showing the highest value in terms of yield. Consequently, Dan Zaria may be the most tolerant and could be used in tomato breeding programs to increase productivity and as such the germplasm are highly recommended for farmers. Further studies can be done on this germplasm to ascertain its performance under disease infestation as well as other favorable environmental conditions to provide more information on its yield potentials.

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