Agro-Morphological Characterization of Tomato (*Solanum lycopersicum* L.) Collections from Southwest Nigeria.

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ABSTRACT

Agro-morphological characterization of tomato (*Solanum lycopersicum* L.) is important in the determination of the genetic variations of the crop. Meanwhile, there are several tomato landraces and imported cultivars in Southwest Nigeria but they are not well identified or morphologically distinguished. It is therefore necessary to characterise these genotypes in order to understand the inherent diversity present in the area. The experiment was carried out at the Teaching and Research farm of University of Ibadan in 2018. The 25 tomato cultivars used were obtained from the tomato project of University of Ibadan Research Foundation. An Augmented Randomized Complete Block Design with four blocks was used. Data were collected based on the guidelines of Bioversity International for tomato descriptors. Parameter assessed were 36 in number, some of which are: primary leaf measurement, stigma exsertion, fruit colour, leaf attitude, predominant fruit shape, fruit size, fruit width, pericarp thickness, number of locules, mean fruit weight, among others. Data collected were subjected to analysis of variance (ANOVA) using Statistical package for Augmented Design (SPAD) at 5% level of significance. The result showed that about 64% of all the traits vary among the cultivars, out which were nine and fourteen quantitative and qualitative traits, respectively. High diversity was observed in fruit-related traits such as fruit shape; fruit colour and mean fruit weight (CV = 68.77%). Therefore, it can be concluded that the analysis carried out using morphological descriptors highlighted that there a significant level of phenotypic diversity among the tomato collections from southwest Nigeria.

Keywords: *Solanum lycopersicum* L., Characterization, Augmented Randomized Complete Block Design.

Introduction

Tomato (*Solanum lycopersicum* L.) belongs to the family *Solanaceae* which is often called the 'nightshade family'. It has an edible fruit which can be consumed in diverse ways. Tomatoes have botanically berry-type fruits and they are referred to as culinary vegetables, since they serve as one of the ingredients of savoury meals (Ogwulumba and Ogwulumba, 2018). Tomato plants are dicots with a series of branching stems with a terminal bud at the tip that does the actual growing. It has compound leaves and the vines are pubescent. It has been established that tomato originated in the Andes region of South America and it has since been domesticated and remained under cultivation in almost all continents. The tomato was introduced to cultivation in the Middle East by John Barker, British consul in Aleppo circa 1799 to 1825. In Nigeria, tomato is one of the most common vegetables and it is utilized in

almost every household for preparation of several dishes.

Tomato is a frost intolerant plant and requires moderate rainfall and temperature. High rainfall leads to lower productivity as it promotes foliar diseases. Setting of fruits is between 15-30oC temperatures. High night time temperatures (above 30oC) lead to poor fruit setting (Oladitan and Akinseye, 2014). Soil with optimum pH of 5.5-6.8 and adequate nutrient are needed for tomato production, but when these are not fully met, fertilisers can be used. Morphological characterisation involves the description of features using specific phenotypic keys which may reflect genetic variability in crops. Characterisation is necessary because it creates awareness of inherent diversity in plants, which may be explored for greater value (Meena, et al., 2015). Likewise, by assessing the differences in the morphology of a plant, it enables the researcher to determine the diversity within and between the plant populations. Thus, morphological characterisation of tomato elucidates the inherent genetic diversity of the crop.

Morphological characterization does not require sophisticated equipment and it is available for immediate use. It is also a direct means of measuring the phenotypic characteristics of a plant. The limitation of using morphology in characterisation is that the environment is subjected to changes which may affect the organism in question and this may affect the information gathered. This is why De Vicente and Fulton (2003) emphasised that morphological characterisation should be conducted by individuals knowledgeable of the species. Despite this limitation, the agro-morphological

studies of plants have no substitute and it can also be used along with advanced biotechnological tools (Bayorbor et al., 2010). Also, morphological characterisation is essential to define the characteristics of local varieties for their protection and registration as recognised conservation varieties. The morphological characters of plants have been in use for genetic characterisation before the advent of molecular markers (Patterson and Weathercup, 1984; Mignouna et al., 1996). These characters have been used widely to identify varieties and even species of different crops. Tomato landraces represent a wealth of interesting traits such as biotic stress-resistance and high quality fruits (Acciarri et al., 2010).

They are among the most important sources of genetic variation within the cultivated tomato and to date, a large number of local varieties have been collected (Robertson and Labate, 2007), which provide a potential for increasing the genetic variation in modern breeding (Hoisington et al., 1999; Huang et al., 2010). The characterization of landraces is imperative for their efficient use in plant breeding and to improve crop production (Fischbeck, 1989) as well as efficient conservation. Exploitation of landraces also requires the study of their genetic diversity structure (Van Hintum and Elings, 1991). The evaluation of the diversity of a given collection can be based on phenotypic traits, genetic markers or their combination (Xu et al., 2013).

There are a lot of tomato landraces in Southwest Nigeria but they are not clearly identified. Since most farmers are not really aware of agro-morphological characters of different varieties and their importance, they often unknowingly

cultivate similar or the same varieties. This may be as a result of different names being given to the same variety in different localities. This often creates a challenge for breeding and may lead to reduced productivity because morphological characters also include the yield attributing characters.

In nearly three decades, few tomato varieties has been released in Nigeria (NACGRAB and NASC, 2013) and those released earlier were restricted to the Northern Guinea Savanna and the Sudan savanna due to the climatic conditions which favours the plants in that environment. Therefore, the results obtained from this study can contribute to information for plant breeders to develop well adapted and high yielding varieties for the Southwest and also to serve as a basis for further studies, such as the molecular characterisation. The main objective of this study therefore is to assess the genetic variations of tomato collections from Southwest Nigeria through morphological characterization.

Materials and Methods
Field sampling procedure:
A field survey of tomato farms was conducted in southwest Nigeria as part of the objectives the Tomato Project of University of Ibadan Research Foundation, in the Department of Crop Protection and Environmental Biology. The states covered include Lagos, Ogun, Oyo, Osun, Ekiti and Ondo. The Agricultural Development Programme (ADPs) facilitated access to farms and farmers using their state zoning template. Two zones were selected per state and 10 farms were sampled per zone for collection of tomato germplasm and other project activities. Farm and farmer selection was conducted by the extension team following

standard procedure. Dried seeds were collected from farmers when available. Otherwise, fresh ripe tomato fruits were collected. Fruit characteristics were described after which seeds were extracted from the fruits and processed. All seeds were airdried and placed in well labelled sealed seed envelopes, then stored in a desiccator until required.

Plant Material and Experimental Design:
Tomato collections from different farms in Southwest Nigeria were used for this study and this experiment was carried out between the month of April and August, 2018. It was a field experiment, carried out at the Teaching and Research Farm, University of Ibadan, Ibadan (7°27′14″N, 3°53′29″E). The 25 varieties evaluated in this study were selected based on quantity of seed available and location of collection.

The experiment was laid out in an Augmented Randomized Complete Block Design with four blocks. In the Augmented design the check cultivars (UC82B and Beske) were replicated in a standard experimental design while the 23 test cultivars selection from the previous seed collection of UIRF were not replicated. Four blocks were used in all and 1 m spacing was left between each block. Inter and intra row spacing of 0.9 m and 0.6 m was maintained respectively with ten plants per test cultivar making up a planting row. There were seven test cultivars in Block I while Block II, III and IV had six, five and five test cultivars, respectively. The two checks were represented in each block.

Nursery preparation and transplanting:
The seeds were first pre-germinated in the Nematology laboratory of the Department of Crop Protection and Environmental Biology,

University of Ibadan (7⁰27′01″N, 3⁰53′48″E). They were placed and grown in Petri-dishes with moist cotton wool and tissue paper. After the seeds had germinated, they were carefully transplanted into the seed tray filled with moist soil, for the nursery purpose, in the Screen house at the Departmental roof-top garden for 21 days, after which they were transplanted unto the field. Standard agronomic practices such as watering, shading and mulching were carried out in the nursery.

Prior to transplanting, the field was cleared, tilled and marked out. After two weeks the field was sprayed with contact and pre-emergence herbicides in order to maintain a long weed-free period. Transplanting was conducted one week after. On the field, the seedlings were transplanted manually with inter-row and intra-row spacing of 0.9m x 0.6m respectively. The varieties were assigned at random to the blocks, that is, each block had an equal chance of being assigned a particular treatment (variety). After transplanting, all necessary agronomic practices, such as watering, weeding were also carried when necessary.

Phenotypic analysis:

The phenotypic characterization was carried out by assessing agronomic conventional traits, both phenological and morphological traits according to the guidelines of the Bioversity International, formerly IPGRI (http://tinyurl.com/n7k75m6). The registered descriptors are:

1)   Quantitative descriptors:

Primary leaf length (cm), Primary leaf width (cm), Days from transplanting to flowering (number of days), Ripening date from transplanting (days), Number of flowers per inflorescence, Number of leaves, Leaf length (cm),   Leaf width (cm), Leaf length/width, Number of fruits per cluster, Mean fruit weight (g), Fruit length (cm), Fruit width (cm), Fruit length/width, Number of locules,   Pericarp thickness (cm) and Vine length (cm).

2)   Qualitative descriptors:

Hypocotyl colour, Hypocotyl colour intensity, Seedling vigour, Inflorescence type, Corolla colour, Stigma exertion, Corolla blossom type, Exterior colour of immature fruit, Leaf attitude, Plant size, Plant growth type, Exterior colour of mature fruit, Predominant fruit shape, Presence of green trips (green shoulder), Green shoulder intensity, Fruit size, Fruit cross sectional shape, Shape of pistil scar and Fruit blossom end shape.

Statistical analysis

Data obtained (Quantitative) were subjected to Analysis of variance at 5% level of significance using Statistical Package for Augmented Design -SPAD, V2.0 (Rathore, Parsad and Gupta, 2004). Quantitative data obtained in the nursery were analyzed with T-test at 5% level of significance. All Qualitative data were analyzed using descriptive statistics.

Results

A total of 34 varieties of tomato seeds were collected across all the states (Table 1). Nine varieties of tomato were collected from Oyo State. Osun state had three varieties of tomato available. Alausa (desigated as Alausa Osun) was the most common among the farms visited. In Ekiti state, six varieties of tomato seeds were collected and most of the farms visited planted improved or imported tomato varieties. In Ogun state, 11 of tomato varieties were collected and generally farmers preferred royal, beske and kerewa type for planting across the ADP zones.

In Lagos state and Ondo state, three varieties each of tomato were collected among the farms visited. Other collections outside of the survey from home gardens, research institutes and seed distributors in Ibadan are listed in Table 2.

Table 1: List of tomato varieties collected from field survey of Southwestern Nigeria in 2017

No.	Name Variety	State	No.	Name Variety	State
1	Arewa	Oyo	18	Royal	Ogun
2	Tyre type	Oyo	19	Baccarat	Ogun
3	Alausa	Oyo	20	Big beef	Ogun
4	Beske	Oyo	21	Roma	Ogun
5	Ibadan local	Oyo	22	Tyre type (small)	Ogun
6	Kerewa	Oyo	23	Kerewa (oblong)	Ogun
7	Royal	Oyo	24	Beske	Ogun
8	Cherry	Oyo	25	Padma	Ogun
9	Alausa	Osun	26	Beske	Ogun
10	Rounded Cherry	Osun	27	Better boy	Ogun
11	Ibadan Local	Osun	28	Small fry	Ogun
12	Toma pepper	Ekiti	29	Uc82b	Ondo
13	Alausa	Ekiti	30	Alausa Olomi	Ondo
14	Caterpillar	Ekiti	31	Beske	Ondo
15	Samrudti	Ekiti	32	Alausa	Lagos
16	Beske	Ekiti	33	Royal	Lagos
17	Better boy	Ekiti	34	Big beef	Lagos

Quantitative traits:

The cultivars show significant differences in nine out of 17 quantitative traits that were measured. This is evident in some traits like, Number of leaves, Number of locules and Mean fruit weight with wide variation as observed in their coefficient of variation of 50.50%, 32.73% and 68.77% respectively (Table 3). No wide variation was observed in the primary leaf length among the cultivars with coefficient of variation (CV) of 20.98%. Arewa had the highest value of 2.09 cm and Cherry F had the lowest value of 0.94 cm. Likewise, low variations also occur among the cultivars with respect to their primary leaf width CV of 27.12%. UC82B had the highest value of 0.99 cm, while Alausa-Ogburo had the lowest width of 0.32 cm (Table 3). The mean differences between the primary leaf length and width is significantly different.

Table 2: List of tomato varieties collected from other sources

No	Variety	Source	No	Variety	Source
1.	Beske - M	Bodija market	16.	L00170 - cherry	NAGRAB
2.	Royal - M	Bodija market	17.	NGB01301	NAGRAB
3.	Tima	Seed store	18.	Shanty	Seed store
4.	Toma VF	Seed store	19.	NGB01302	NAGRAB
5.	Roma VFN	TAMU, USA	20.	Nemonetta	Dizengoff
6.	Small fry	TAMU, USA	21.	NG/AA/Sep/091/053	NAGRAB
7.	Kerewa	Ijaiye market	22.	NG/RM/Jan/00/001	NAGRAB
8.	Ibadan local	IITA	23.	NG/MR/May/o9/1006	NAGRAB
9.	Better boy	TAMU, USA	24.	Nirvana	Seed store
10.	L00169 - cherry	NAGRAB	25.	Rio - Grand	Seed store
11.	UC82 B	Seed store	26.	NGBO1665	Seed store
12.	Roma Savana	Seed store	27.	BESKE	Seed store
13.	UC 82 B	Seed store	28.	Marmande	Belgium
14.	Roma - M	Bodija market	29.	Brandywine	Seed store
15.	Tropmech tomato	Seed store	30.	Ibadan local	Sango market

There were no significant differences in the number of flowers per inflorescence among the cultivars and across the blocks with Rodeo 62 and Cherry F having the lowest and highest value of 4.25 and 10.00, respectively. There was a low variation among the cultivars with coefficient of variation (CV) of 19.04%. Also, with the interaction of the checks cultivars and the treatments show no significant differences. A Coefficient of variation of 26.02% showing a low variation was observed in the number days to flowering from transplanting. Also, no significant differences were observed among the cultivars with Rounded cherry having the lowest number of days of about 22 days to flowering as compared to UC82B which had the highest value of 57days.

Significant differences were not observed in the number of days to fruit ripening from transplanting. Very low variation was observed among the cultivars and this can be seen in the coefficient of variation with 7.62%. The lowest (63 days) and highest (87 days) values were recorded for Cherry F and Tropimech, respectively (Table 3). There were no significant differences among the cultivars with respect to their number of fruits per cluster. Although, little variation was observed with UC82B having the lowest value of one fruit, while Caterpillar had the highest number of fruits of ten fruits.

The differences observed here may be due to some environmental factors rather than differences among the treatments. Which means, no observed significant differences among the cultivars as regards their fruit length with Cherry F having the shortest leaf length of 15.44 cm, while Alausa (zone 2 Ekiti) had the

longest leaf length of 38.62 cm. There were significant differences among the cultivars leaf width, with Cherry F having the shortest leaf

width of 10.55 cm and Alausa (zone 2 Ekiti) having the widest leaf width of 33.32 cm.

Table 3: Quantitative traits of some tomato cultivars from Southwest Nigeria:

Traits	Mean	Min	Max	SD	SE	CV (%)
Primary leaf length (cm)	1.49*	0.94	2.09	0.31	0.07	20.98
Primary leaf width (cm)	0.47*	0.32	0.99	0.47	0.03	27.12
Number of flowers / inflorescence	6.23[NS]	4.25	10.00	1.19	0.22	19.04
Transplanting-flowering (days)	35.16[NS]	22.00	57.00	9.15	1.67	26.02
Transplanting-fruit ripening (days)	72.52[NS]	63.00	87.00	5.52	1.01	7.62
Number of fruit per cluster	4.04[NS]	1.00	10.00	1.85	0.34	45.69
Leaf length (cm)	27.56[NS]	15.44	38.62	4.64	0.85	16.83
Leaf width (cm)	19.75*	10.15	33.32	4.81	0.88	24.35
Leaf length / leaf width	1.42[NS]	1.10	1.77	0.16	0.03	11.24
Number of leaves	58.25*	19.50	123.00	29.67	5.41	50.50
Vine length (cm)	112.44*	61.85	201.25	29.51	5.38	26.24
Fruit length (cm)	3.62[NS]	1.27	5.23	0.91	0.17	25.38
Fruit width (cm)	3.49*	1.35	5.68	1.01	0.18	28.79
Fruit length / fruit width	1.08*	0.74	1.60	0.34	0.66	31.59
Pericarp thickness (cm)	0.43[NS]	0.11	0.68	0.11	0.02	26.41
Number of locules	2.72*	2.00	5.56	0.89	0.16	32.73
Mean fruit weight (g)	26.84*	1.17	93.37	18.45	3.37	68.77

Min: minimum value   Max: maximum value   SD: Standard deviation, SE: Standard error, %CV: Coefficient of variation, (*)=significant at 0.05 level of significance, NS= not significant.

Even though the coefficient of variation was low (24.35%), there were still significant differences among them (Table 3). No significant differences were observed in the ratio of leaf length to leaf width among the cultivars. This is also reflected in their coefficient of variation of 11.24%, showing very low variability with respect to this trait, even though Rodeo 62 had the lowest value of 1.10 and Rounded cherry with the highest value of 1.77 (Table 3). Among the cultivars within and across the blocks, there were significant differences in their number of leaves with

Tropimech and NG/MR/MAY/09/006 having the lowest value of 19.5 and Cherry F having the highest value of about 123 leaves. There were variations among the cultivars with coefficient of variation of 50.50%. The cultivars shows significant differences in their vine length as well, where Samrudti had the shortest vine length of 61.85 cm and Kelvin f1 had the longest vine length of 201.25 cm. Among the tomato cultivars, there were no significant differences in their fruit length, while the fruit width showed some level of significance. Cherry F had the lowest fruit

length of 1.27 cm and the lowest fruit width of 1.35 cm. Baccarat had the highest fruit length (5.23 cm) and width (5.68 cm). There were observed variation, although low among the cultivars, with their coefficient of variation showing 25.38% and 28.79% for fruit length and width respectively.

Ratio of fruit length to width was significant among the cultivars. Alausa (zone 2 Ekiti) had the lowest ratio of 0.74, while Alausa-Ogburo had the highest ratio of 1.60. The coefficient of variation among the cultivars is 35.59% showing the level of variation. No significant differences were observed in the Pericarp thickness among the treatment cultivars. The differences observed were among the check cultivars within and across the blocks. This might have contributed to the little variation observed with Cherry F having the lowest value of 0.11 cm and Baccarat having the highest value of 0.68 cm. There were significant differences in their number of locules with Rodeo 62 having the highest value of 5.56, while UC82B, Kelvin f1, Alausa-Ayetoro, Royal, Evergreen, Caterpillar, Alausa-Ogburo, Rounded cherry and Tropimech had the lowest values of 2 locules. There were significant differences among the cultivars with respect to mean fruit weight. Wide variation was also observed, where the coefficient of variation was 68.77%. Lowest value of 1.17g per fruit was recorded for Cherry F, while Baccarat had the highest weight of 93.37 g per fruit.

Qualitative traits
Among the qualitative traits observed, fourteen traits showed some level of variability and only five showed low or no variability. Variations were evident in seedling characteristics with hypocotyl colour intensity, seedling vigour, and plant size (Figure 1). Vegetative traits such as growth type and leaf attitude also showed variation. Majority (48%) of the varieties were in determinate, while 40% were indeterminate with a few being semi-determinate (Figure 2A). Most (52.7%) of the varieties had leaf horizontal attitude while some (23%) were semi-erect, the others represented <25% leaf type (Figure 2B). Observations from the inflorescence characteristics also showed variation, with almost 90% of the tomato varieties showing uniparous inflorescence type (Figure 3A) and 80% showing inserted stigma exsertion (Figure 3B). The pistil shape was mainly the dot type in 68.5% of the tomato varieties (Figure 3C) and blossom end shape was also mainly flat (57%), also some (20%) were pointed while the others types were <10% each represented 2 varieties in each category (Figure 3D).
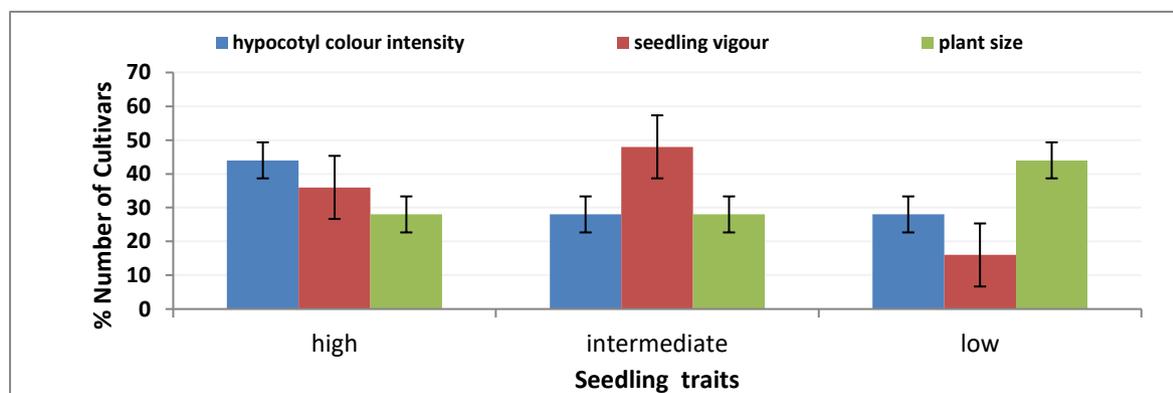
Figure 1: Hypocotyl colour intensity, seedling vigour and plant size of some tomato cultivars from Southwest Nigeria
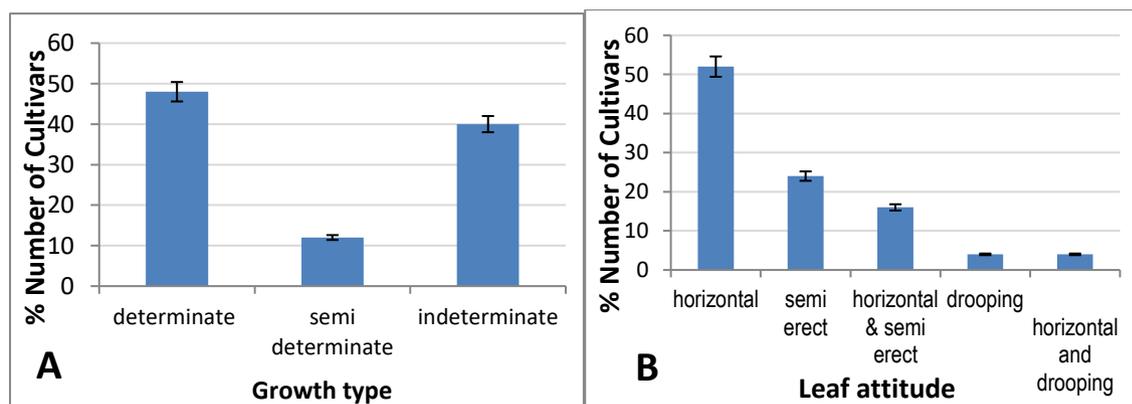

Figure 2: Plant growth type (A) and leaf attitude (B) of selected tomato cultivars from Southwest Nigeria

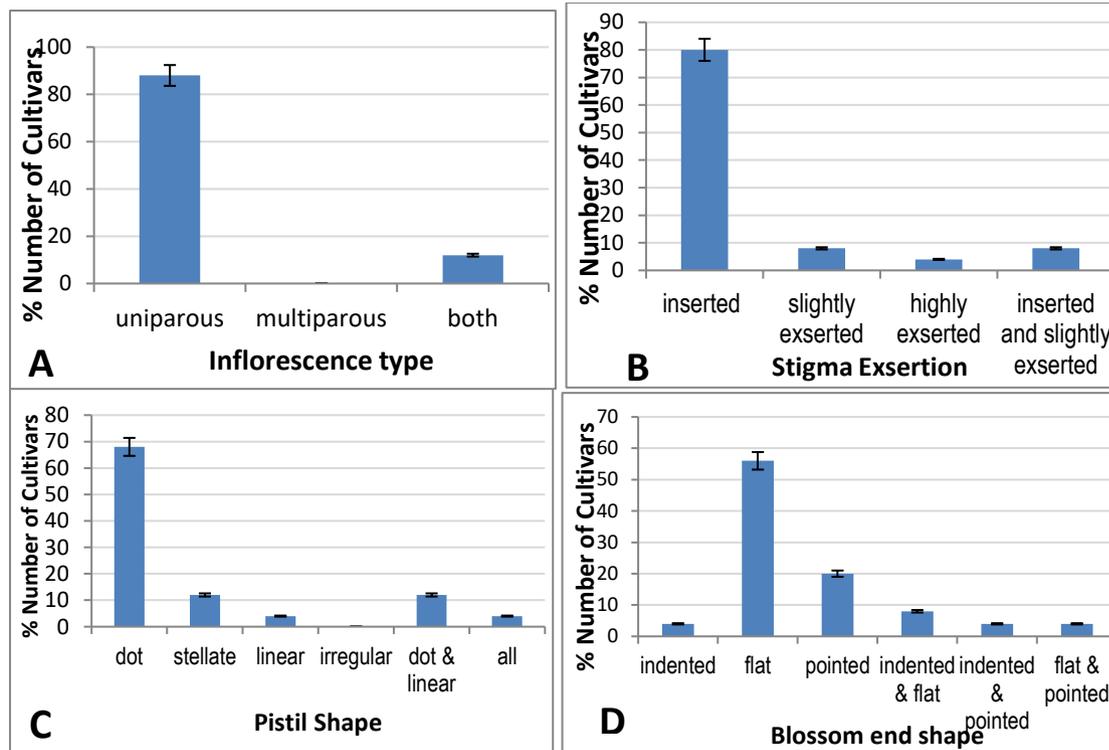Values are means 10 plants; error bars represent standard error.

Figure 3: Percentage number of tomato plants showing selected Inflorescence characteristics of some tomato cultivars from Southwest Nigeria

Values are means 10 plants; error bars represent standard error. Inflorescence type (A), stigma exertion (B), pistil shape (C) Blossom end shape (D);

Almost all the fruit characteristics measured showed variation. Immature fruit colour was dark green in 40% of the tomato varieties evaluated while 38% of them were light green (Figure 4A). On maturity, most fruits were orange in colour (60%), 32% were red and <10% were pink, however, there were no yellow coloured tomato fruits among the varieties evaluated (Figure 4B).

Fruit shape was mainly slightly flattened (48.4%), followed by cylindrical and heart-shaped (lobbed) with a few rounded ones

(Figure 4C). In cross-section, fruit shape was angular for most (51%) varieties and those that were round represented 28% (Figure 4D). Majority of the fruits were small (60%) to intermediate (12%) in size (Figure 4E). Other characters such as presence of green shoulder, green shoulder intensity, hypocotyl colour, corolla colour and corolla blossom type showed no variation (P> 0.05). The yield of the varieties also varied, varieties with significantly higher yields were Thorgal F1 and Ibadan local followed by tire type (lobbed) compared to the other varieties. Moderate yields were obtained

from beske, UC82B, RomaVF, Alausa and Tropmech varieties (Figure 5).
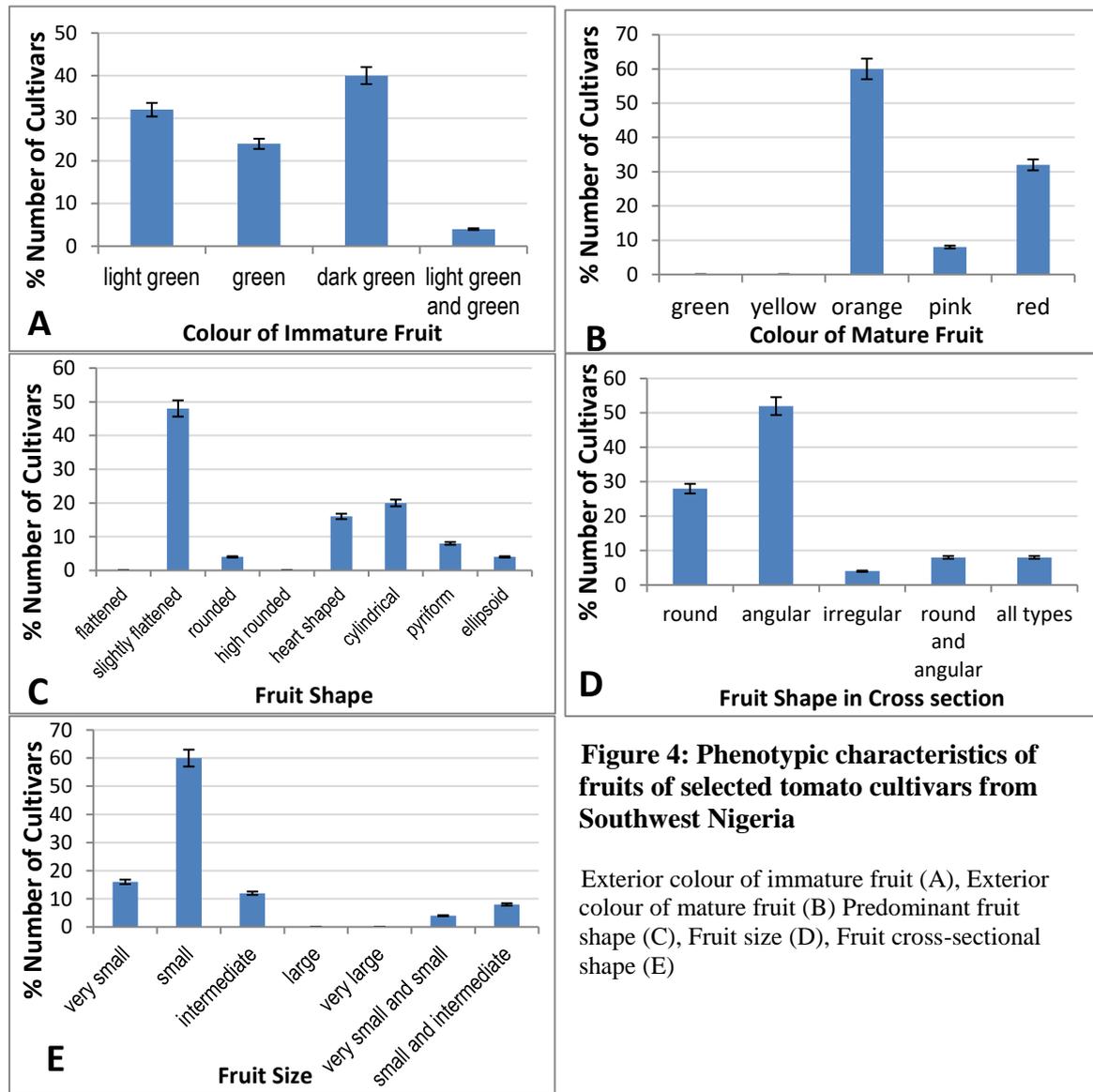

Figure 4: Phenotypic characteristics of fruits of selected tomato cultivars from Southwest Nigeria

Exterior colour of immature fruit (A), Exterior colour of mature fruit (B) Predominant fruit shape (C), Fruit size (D), Fruit cross-sectional shape (E)
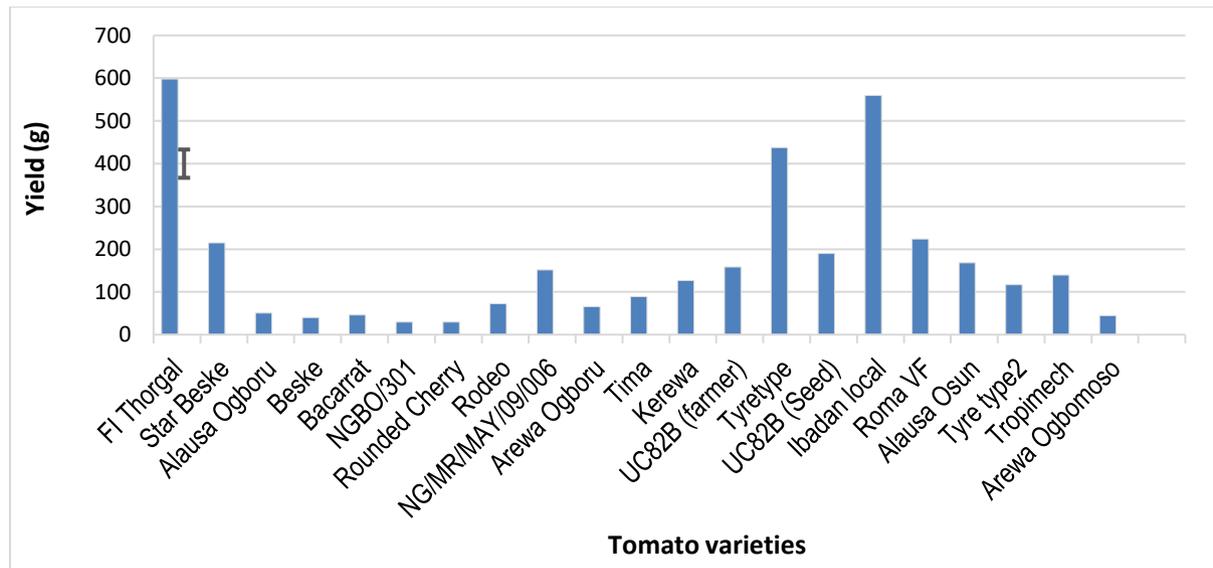
Figure 5: Yield (g) of selected tomato varieties representing collections from southwestern Nigeria

Correlation Analyses

Correlations Analyses were carried out on the quantitative traits to know their strength of association. For instance, moderate and positive correlation were observed between fruit weight and fruit length, with a Correlation coefficient of 0.6087 while fruit width was strongly and positively correlated with the fruit weight

(Correlation coefficient of 0.8687). There was positive Correlation between number of flowers per inflorescence and number of fruits per cluster which was moderate with coefficient of 0.4813. Relationship between days from transplanting to flowering and days from transplanting to ripening shows the same trend with a coefficient of 0.5759 (Table 4).

On the other hand, negative correlation was observed between the numbers of days from transplanting to flowering and number of leaves with coefficient of -0.5581. Between number of days from transplanting to fruit ripening and number of leaves there was negative correlation as well with coefficient of -0.6835 (Table 4)

Table 2.0: Estimates of Correlation Analysis for all Quantitative traits of some tomato cultivars from Southwest Nigeria:

Traits	FL/FW	FL	MFW	FW	LL	LW	LL/W	NOL	NOLC	PT	VL	DTF	DTFR	NFI	NFC	PLL
FL	0.5015*															
MFW	0.2029*	0.6087*														
FW	0.4415*	0.5274*	0.8687													
LL	-0.0334	0.3735	0.5251*	0.5163*												
LW	-0.0673	0.5076*	0.6353*	0.6882*	0.8772*											
LL/W	0.0388	0.5177*	0.5282*	0.6214*	-0.3368	0.7354*										
NOL	0.2176	-0.3114	-0.2938	0.5081*	-0.0454	-0.2286	0.4127*									
NOLC	0.4227*	0.1303	0.5528*	0.6397*	0.4391	0.5711*	0.4177*	-0.1005								
PT	0.0305	0.6873*	0.6394*	0.643*	0.3057*	0.4233*	0.4872*	0.6361*	0.1064							
VL	0.0373	-0.2178	-0.0505	-0.2291	0.3038	0.0321	0.3773	0.5005	-0.0173	-0.2544						
DTF	-0.0527	0.1045	-0.0661	0.095	-0.2348	-0.0692	-0.2175	-0.5581	-0.2727	0.3569	-0.4602					
DTFR	-0.3409	0.1278	0.1693	0.455	0.1045	0.2584	-0.3534	-0.6835	0.1476	0.4613	-0.3959	0.5759				
NFI	0.0737	-0.457*	0.4609*	0.5182*	-0.2349	-0.2511	0.2025	0.3777	0.3005*	0.6267*	0.2603	0.2079	-0.3357			
NFC	0.137	0.3844*	0.4467*	0.4999*	-0.0112	-0.1608	0.3463	0.2904	-0.3543	0.4505*	0.3619	0.0397	-0.1664	0.4813*		
PLL	0.221	0.1751	0.1213	-0.0253	0.2099	0.0284	0.2383	0.1411	0.1911	0.142	0.1028	0.3425	-0.2614	-0.0417	0.0749	
PLW	0.0808	0.1254	0.2015	0.0595	0.2444	0.1004	0.1349	-0.0071	0.1186	0.2739	0.0545	-0.036	-0.1277	-0.1678	0.0623	0.8117*

NFI: Number of flower per inflorescence, DTF: Days from transplanting to flowering, DTFR: Days to fruit ripening from transplanting, NFC: Number of fruit per cluster, LL: Leaf length, LW: Leaf width, LL/LW: Ratio of leaf length to leaf width, NOL: Number of leaves, VL: Vine length FL: Fruit length FW: Fruit width FL/FW: Ration of fruit length to fruit width PT: Pericarp thickness NOLC: Number of locules MFW: Mean fruit weight PLL: Primary leaf length,   PLW: Primary leaf width, Asterisk(*): significant at 0.05 level of significance.

Discussion

From this study, the analysis carried out on the 36 morphological and agronomic descriptors assessed indicate that the tomato collection was characterized by different levels of phenotypic variation. About 64% of all the traits vary among the cultivars with 36% being common if not nearly the same in all the cultivars. The variation observed within the same cultivar may be attributed to environmental influences (Ezekiel, *et al*., 2011). Another factor which may also be attributed to this variation is outcrossing and this may be as a result of the different positions of the stigma on a flower (Chen and Tanksley, 2004). For instance, in some traits like fruit cross-sectional shape and shape of pistil scar, Rounded cherry cultivar had all the different types of the traits. Therefore, outcrossing may enhance the genetic variability of the crop.

Nine out of the 17 quantitative traits showed significant differences among the cultivars and this may be due inherent genetic factors which cause them to possess these traits in varying degree. These also occur among the qualitative traits, where 14 traits showed high variability and only five showed no variability. (Marasini and Paudel, 2017). The differences observed in the remaining quantitative traits may be due to some other factors and not the treatment and could be as a result of different genotypes performing differently in the same environment.

High variation was observed most especially with traits related to fruit such as the mean fruit weight among the cultivars. Also, high diversity was seen in the fruit shape and fruit colour at maturity, all of which are traits that are of major interest in fresh market cultivars and in breeding programmes (Foolad, 2007). When considering the qualitative traits in this study, genetic diversity was quite evident, where the cultivars possess all the different levels of the traits. This is similar to what Terzopolos and Bebeli (2010) observed where 34 Greek tomato landraces were found to be similar in several qualitative traits, such as the plant growth type, leaf attitude, inflorescence type, the predominant fruit shape, fruit cross-section shape, blossom end shape, fruit colour, and the shape of pistil scar. In addition, as reported by Marasini and Paudel (2017) on the phenotypic characterisation of some tomato landraces in Nepal, mean fruit weight was found to be highly significant while number of flowers per plant was not significantly different among the tested landraces. This agrees with the present study, although with different genotypes and environment.

Different types of relationships were observed among some traits when Correlation analysis was carried out. For example, positive relationships between the number of flowers per inflorescence and number of fruits per cluster signified that, the more the flowers, the more the number of fruits per cluster. Also, positive association observed among fruit weight, fruit width and fruit length means that increase in the fruit width and length, add more weight to the fruit. Some traits on the other hand showed negative correlation, for example the relationship between number of days from transplanting to flowering and number of leaves

was an indication that higher number of leaves delayed the reproductive stage of the crop (Wang *et al.* 2016)).

In all, there was high level of genetic diversity among the cultivars with respect to their phenotypic traits, which can pave way for the improvement on or the development of suitable varieties.

The tomato collections showed appreciable variability with regard to their quantitative and qualitative traits. Sufficient diversity was observed among some of the tomato varieties from southwest Nigeria which may be suitable to change the perception of some tomato breeders as well as some farmers that some cultivar that was believed to be similar are actually different from one another. Similar cultivars possessing different phenotypic characteristic may be attributed to response to environmental influences. The analysis carried out using morphological descriptors highlighted that the present collection is

characterized by significant level of phenotypic variation. This supports the observation of Scintu (2013) that reasonable results can be obtained from these descriptors which may be useful to plant breeders for further investigations and this is also in line with the conclusion of Ezekiel, *et al* (2011).

Therefore, the understanding of the knowledge of the phenotypic variation of tomato is important in breeding programmess and also enhances the productivity of the crop. To further this study, characterization of tomato using morphological descriptors can be combined with molecular tools to determine these differences at molecular level so as assign the cultivars into varieties and to avoid error in varietal naming. Since, most of the traits related to market values show different levels of variability, further study can bring about the development of new and well adapted varieties. This is recommended as the next activity for the tomato project of the UIRF.

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