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Morphological Characterization of Tomato Samples from Northern Nigeria

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Keywords: Tomato; Morphological characterization; Northern Nigeria.

Abstract

Nineteen (19) tomatoes Samples were collected from seven states in Northern Nigeria based on their commercial availability. Seeds were extracted from ripe matured fruits and these were later sun dried for one month and sowed in the screen house of the Soil microbiology unit, International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria on sterilized Alfisol soil of the Egbeda series. Six seeds per pot were sown directly in the soil which were later thinned to one plant per stand two weeks after germination. Agro-morphological dendrogram result showed all 19 samples of tomatoes distinct at 100% similarity coefficient but at lower similarity index there were 4 clusters without any recourse to the different sampling locations. Morphological characters examined for morphological include cross-sectional shapes, core, pericarp and matured fruits color, the overall fruits shape, size and firmness according to tomatoes descriptor. Significant differences ($p < 0.05$) exist amongst the 19 samples studied for various parameters studied which includes the fruit width, fruit length, thickness of the fruit wall, single fruit weight per plant and the total fruit weight per plant. The sample with the highest fruit width was Kaduna Tangino (46.00) while the lowest was found in Nassarawa roma1 (24.50). Dan India (98.50) and Kano tangino (37.50) had the highest and lowest values for fruit length respectively. The present study provides evidence that could support targeted breeding programmes in the studied samples for crop improvement.

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Introduction

In tropical Africa, the area used for tomato cultivation is about 300,000 ha with an estimated annual production of 2.3 million tonnes; Nigeria is the largest producer accounting for 541,800 ha and an annual production of 2,143,500 tonnes and ranks 14th in the world in production, and 3rd in hectares of land cultivated [1]. Tomato, which is scientifically called *Solanum lycopersicum* L. [2] is a major fruit vegetable [3] which provides employment to the people hired to work in the farms, and a source of income to the tomato farmers. Tomato fruits contain calories, vitamins and minerals [3]. It improves the nutrient quality of the stews and salads (when used as one of the ingredients), that are part of the wide variety of dishes (Foods) prepared in hotels and homes of different Nigerian communities and the entire world. Tomato has very high moisture content and water activity which makes it susceptible to microbial growth and senescence, resulting in about 30 % post-harvest losses every year in Ghana [4]. To mitigate these challenges, Owureku-Asare et al. [5] produced consumer-acceptable and shelf-stable tomato powder by use of a solar drier. This drying technique (solar drying) is less expensive and can effectively and efficiently reduce postharvest losses [6]. However, the food use of tomato powder is limited; generally being used as an additive (such as for flavour, taste and colour) during food preparation rather than a main ingredient for soups and stews as may be desired by the Nigerian consumer [7].

The variation in the quantity and quality of the available tomato fruits results from negative production factors, which include pre-harvest diseases, notably early blight, mould rot [8,9, 10], tomato wilt [11], and infection by pathogens after harvest leading to fruit rots [2]. Postharvest fungal and bacterial infections cause fruit rot and spoilage, consequently, negatively affecting the value of the harvested fruits [13]. The spoilt, rotten tomatoes are usually discarded by the commodity handlers, between harvesting and consumption. The discarded spoilt tomatoes are regarded as postharvest loss, and are a reflection of the economic loss to tomato handlers and appropriate agricultural revenue generating agency.

The quantity of tomato fruits losses after harvest, is however, determined by the tomato variety and the fruit colour maturity stage at harvest [14,15], and magnitude and nature of losses is influenced by postharvest handling procedures. The easily damaged varieties are prone to injury during postharvest handling [16]. The level of injury determines the amount of postharvest losses because the injuries are avenues through which infection occurs [17,18, 19,20], resulting to the rotting of the fruits. Besides, losses are even greater for tomatoes that are harvested when the fruits are over mature (red stage of maturity) because such fruits are easily damaged [15]. The degree of spoilage on the tomatoes harvested at the different fruit colour (green, yellow, red) maturity stages is similarly affected by the postharvest handling procedures [3], particularly sorting, packaging, transport containers and means of transport [13]. All these factors cumulatively determine the extent of fruit spoilage by the time they reach the consumer [22,23,24].

Morphological characters have for a long time remained the means of studying genetic variations in plant species. Morphological data are affected by ecological interactions; thus, explanations must be made with suitable replication [25]. Valid comparisons are only possible for accounts taken at the same location and during the same 13 seasons. Analysis of variance revealed highly significant differences among genotypes for days to emergence, days to 50 percent flowering, number of pods per plant, weight of pods per plant (g), pod length (cm), number of seeds per pod, 100-seed weight (g) and green pod yield (kg/plot). The correlation studies revealed that in general, estimates of genotypic correlation coefficient were higher than corresponding phenotypic correlation coefficient. The results suggested that these traits could be considered as major green pod yield contributing characters in garden peas. 100-seed weight, number of pods per plant, number of seeds per pod and days to 50 percent flowering exhibited maximum positive direct effect on green pod yield per plot, respectively. It indicated that these are main contributors towards yield [26].

Akinfasoye et al. [27] conducted field experiment at National Horticultural Research Institute of Nigeria (NIHORT), Ibadan during wet and dry seasons of 2009 and 2010 respectively to investigate the relationships among agronomic traits of 10 tomato hybrids. The data obtained on vegetative and fruit parameters were analysed combined by analysis of variance and Least Significant Difference at 5% probability was used to test significance. Both the vegetative growth and fruit yield of tomato were superior in the drier season. It was found that selection cannot be reliably inferred from fruit width. Tomato with fewer leaves can be selected for high fruit producers. These varieties are also likely to flower earlier. Based on this, number of leaves can be used to select early maturing varieties. Tall tomato plants can be assumed to branch more and produce heavier fruits [27]. Conclusively, number of leaves, days to 50% flowering, number of fruits plant, number of branches and 1 fruit weight can to a large extent be used to select high yielding varieties. [28] studied twenty-six morphological traits as well as 47 single nucleotide polymorphism and simple sequence repeat markers to investigate genetic variation in 67 tomato (*Solanum lycopersicum* L.) varieties collected from Argentina between 1932 and 1974. Approximately 65.0% of the morphological traits and 55.3% of the molecular markers showed polymorphisms in the 67 varieties.

Nwosu *et al.* [29] studied the extent of genetic variability among 19 accessions of tomato (*Solanum* spp.) using genetic variability parameters as a basis for harnessing of the crop. High significant differences among the accessions for all attributes studied. Cluster analysis based on 37 agro-morphological attributes separated accessions into two distinct groups according to the fruit types i.e. cherry and classic fruit types. Values for genotypic and phenotypic coefficients of variation showed variability among the accessions. Correlation analysis showed fruit per plant is positively and significantly correlated to plant height, number of branches per plant and leaf length. Very high genetic advance and heritability estimates for leaf length, leaf width, days to flower, days to 50% flowering, number of fruits per plant, fruit length, fruit diameter, fruit weight and 1000 seed weight suggest simple inheritance system and thus amenability for these attributes to selection in tomato improvement [29]. The aim of this study is to investigate the morphological features of 19 tomato samples obtained from Nigeria for crop improvement programmes.

Materials and methods

Preliminary survey was conducted around the Northern States in Nigeria. After the field assessment**,** seven states were selected based on availability of tomato fruits from major markets located in Kano, Katsina, Bauchi, Nassarawa, Niger, Plateau and Kaduna states. The samples were kept in clean zip-lock bags and taken to the laboratory immediately for further studies. To-

mato fruits available in five major market depots within seven states of northern Nigeria were purchased in clean zip-lock bags and taken to the laboratory immediately for further studies. As part of the market survey, the traders were asked specific questions to determine the following: Locations where the tomatoes are cultivated, where they are transported from and local names, means of storage and transportation. Nineteen (19) tomatoes Samples were collected from seven states in Northern Nigeria based on their commercial availability [30]. Seeds were extracted from ripe matured fruits and these were later sun dried for one month and sowed in the screen house of the Soil microbiology unit, International Institute of Tropical Agriculture (IITA), Ibadan on sterilized Alfisol soil of the Egbeda series [31]. Six seeds per pot were sown directly in the soil which were later thinned to one plant per stand two weeks after germination. Morphological characters examined for morphological include cross-sectional shapes, core, pericarp and matured fruits color, the overall fruits shape, size and firmness according to tomatoes descriptor.

Table 1: Source, coordinate and local names of 19 tomato varieties.

Source	Coordinate	Tomato varieties
Bauchi	10.7761° N, 9.9992° E	UTC 1 and UTC 02
Kaduna	10.3764° N, 7.7095° E	Derica sweet, Kaduna tangino, Derica round, Roma zaria 1 and Roma zaria 2
Kano	11.7471° N, 8.5247° E	Dan indian, Kano tangino, Mai Mara
Katsina	12.3797° N, 7.6306° E	Dan Nassarawa, Derica small, Nassarawaroma 1, Nassarawaroma 2
Nassarawa	8.4998° N, 8.1997° E	Nassarawa dan kasa
Niger	9.9309° N, 5.5983° E	Niger roma 1 and Niger roma 2
Plateau	9.2182° N, 9.5179° E 12.1222° N, 6.2236° E	Derica oblong Dan India

Results and discussion

Characterization consists of recording those characters which are highly heritable, those can be easily distinguished by naked eye and are expressed in all environments. Before starting any improvement programme of this crop it is required to collect available germplasm and their characterization is very important for varietal improvement and selection [32]. The evaluation of phenotypic traits such as fruit morphology, color intensity, nutritional quality, firmness, flavor and aroma are challenging and time-consuming because of the quantitative nature of the traits [33]. The morphological characterization of the 19 samples are presented below. Figure 1 shows the 19 samples studied, three main shapes were observed namely; angular, round and irregular. The distribution of the cross-sectional shapes in relation to the samples are angular (UTC 1), Derica round, Dan Indian, Nassarawa Roma1, Nassarawa Roma2, Niger Roma1 and Niger Roma2); round (UTC 02), Derica Sweet, Kaduna Tangino, Roma Zaria 1, Roma Zaria 2, Mai Mara, Derica Oblong and Dan India) while samples with irregular shapes are Kano tangino, Derica small, Dan Nasarawa and Nassarawa Dan Kasa. The distribution of the color of core of the samples are illustrated below. The color ranges from orange, light, pink, red, white and yellow. Two distinct shape of angular and round was observed for most of the samples with the remaining having irregular shapes while four different color of fruit core was observed. 44% white, 17% red and pink, 5% were for orange and yellow while 11% was for variants of other colors. High significant differences were observed for the nine characters studied.

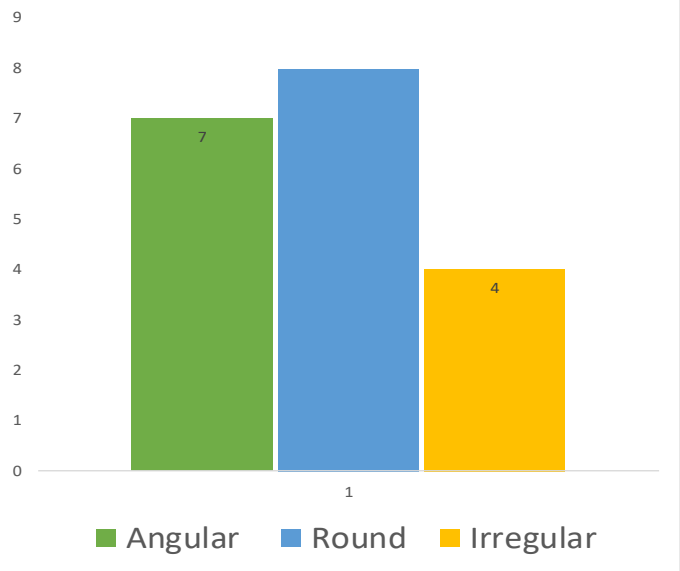

Figure 1: Histogram showing the samples cross-sectional shapes.

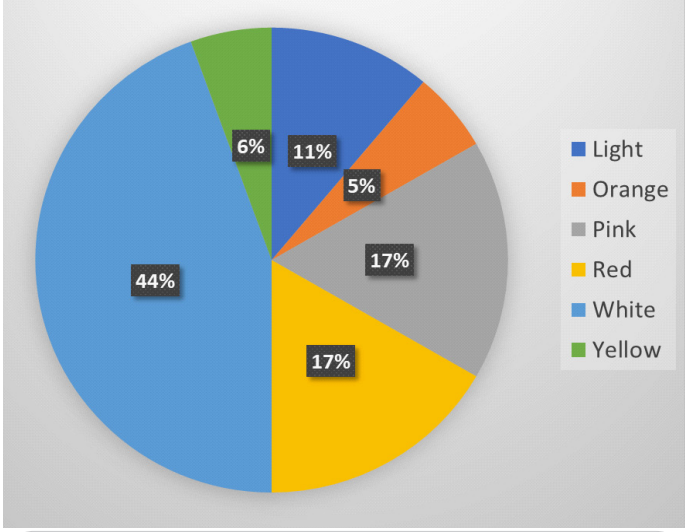

Figure 2: Color of core.

Table 2: Morphological assessment of the 19 tomato samples.

Sample	Location	Fresh color of pericarp	Fruit size	Exterior color of mature fruit	Fruit shape	Fruit firmness
UTC 1	Bauchi	Orange	Small	Red	Slightly flattened	Intermediate
Derica Oblong	Plateau	Light	Small	Red	Slightly flattened	Intermediate
Dan Indian	Kano	White	Small	Red	Rounded	Firm
Kano Tangino	Kano	White	Small	Red	Rounded	Firm

Derica sweet	Kaduna	White	Small	Orange	High rounded	Firm
Kaduna Tangino	Kaduna	White	Small	Orange	High rounded	Firm
Derica Round	Kaduna	Red	Intermediate	Orange	Heart shaped	Soft
UTC 02	Bauchi	Pink	Intermediate	Orange	Heart shaped	Soft
Dan Nassarawa	Nassarawa	Light	Very large	Red	Slightly flattened	Firm
Derica Small	Katsina	Red	Very large	Red	Slightly flattened	Firm
Roma Zaria 1	Kaduna	White	Small	Red	Rounded	Intermediate
Nassarawaroma 1	Nassarawa	White	Small	Red	Rounded	Intermediate
Niger Roma 1	Niger	Orange	Large	Red	Flattened	Firm
Roma Zaria 2	Kaduna	Red	Large	Red	Flattened	Firm
Dan India (Zamfara)	Zamfara	White	Intermediate	Red	Heart shaped	Firm
Nassarawa Roma 2	Nassarawa	Pink	Intermediate	Red	Heart shaped	Firm
Niger Roma 2	Niger	Red	Large	Orange	Slightly flattened	Firm
Nassarawa dan kasa	Nassarawa	White	Intermediate	Red	Rounded	Intermediate
Mai Mara	Kano	Pink	Small	Red	Flattened	Soft

Classified based on the International Board for Plant Genetic Resources tomato descriptor.

In table 2, the distribution of the 19 samples in relation to location, fresh colour of pericarp, fruit size, exterior color of mature fruit, fruit shape and fruit firmness is presented. The sample locations have been described as shown in the map above. The fresh color of pericarp ranges from Orange (UTC1) to Pink (Mai Mara). The samples exhibited various color of the fresh pericarp. The fruit sizes also vary from small (UTC1, Derica Oblong, Dan India, Kano Tangino, Derica sweet, Kaduna Tangino, Roma Zaria 1, Nassarawa Roma 1and Mai Mara) to Intermediate (Derica round, Dan India (Zamfara), Nassarawa Roma 2 and UTC02) and large (Niger Roma 2, Niger roma 1 and Roma Zaria 2). Exterior colour of mature fruit also varies from orange to red while the fruit shapes also vary from rounded, flattened, heart shaped, high rounded to slightly flattened. Soft, intermediate and firm are the basic classification of the 19 varieties according to fruit firmness. These outcomes are similar to previous studies by Olaniyi *et al.* [9] where fruit yield per plant and total fruit yield were statistically significant among the varieties.

Table 3a: Tomato yield parameters.

Samples	FW ± SD	FL ± SD	TFW ± SD	SFWP ± SD	TFWP ± SD
Dan India (Zamfara)	31.00 ± 1.41^{g}	82.50 ± 4.94^{b}	7.50 ± 2.12^{d}	9.80 ± 0.42^{ef}	45.50 ± 0.56^{ij}
Dan Nassarawa	44.50 ± 0.70^{ab}	44.50 ± 0.70^{hg}	10.00 ± 0.00^{bc}	13.90 ± 1.69^{bcd}	69.80 ± 0.42^{e}
Dan Indian	30.50 ± 0.70^{g}	98.50 ± 0.70^{a}	8.50 ± 2.12^{cd}	4.96 ± 0.57^{gg}	45.45 ± 0.00^{ij}
Derica oblong	34.00 ± 1.41^{ef}	64.00 ± 1.41^{c}	9.50 ± 0.70^{bcd}	7.27 ± 0.43^{fg}	41.33 ± 0.00^{j}
Derica round	42.50 ± 3.53^{bc}	52.00 ± 1.41^{ef}	9.50 ± 0.70^{bcd}	17.76 ± 0.03^{a}	76.49 ± 0.00^{d}
Derica small	44.00 ± 1.41^{ab}	50.50 ± 0.70^{ef}	9.50 ± 0.70^{bcd}	12.8 ± 0.98^{bc}	74.30 ± 5.37^{de}
Derica sweet	41.00 ± 2.82^{c}	52.50 ± 3.53^{ef}	9.50 ± 0.70^{bcd}	15.79 ± 0.43^{ab}	153.12 ± 0.00^{b}
Kaduna tangino	46.00 ± 1.41^{a}	43.00 ± 8.48^{ghi}	9.50 ± 0.70^{bcd}	7.04 ± 0.23^{g}	44.90 ± 0.00^{ij}
Kano tangino	43.00 ± 2.82^{bc}	37.50 ± 4.94^{i}	14.00 ± 1.41^{a}	6.71 ± 3.52^{g}	19.89 ± 0.00^{j}
Mai Mara	38.50 ± 2.12^{d}	54.00 ± 1.41^{ef}	11.50 ± 2.12^{b}	13.95 ± 0.21^{bcd}	54.65 ± 1.62^{g}
Nassarawa dan kasa	34.00 ± 1.41^{ef}	37.50 ± 3.53^{i}	10.50 ± 0.70^{bc}	13.10 ± 0.56^{bcd}	44.70 ± 1.41^{ij}
Nassarawaroma 1	24.50 ± 0.70^{i}	66.50 ± 2.12^{c}	9.50 ± 0.71^{bcd}	14.10 ± 0.56^{bc}	53.10 ± 3.81^{gh}
Nassarawaroma 2	28.50 ± 2.12^{h}	56.50 ± 2.12^{de}	4.00 ± 1.41^{e}	11.05 ± 0.91^{de}	49.30 ± 5.93^{ih}
Niger roma 1	34.00 ± 1.41^{f}	56.50 ± 2.12^{de}	7.50 ± 0.70^{d}	12.75 ± 1.06^{cd}	63.10 ± 3.67^{f}
Niger roma 2	33.00 ± 1.41^{ef}	63.00 ± 2.82^{c}	10.50 ± 0.70^{bc}	13.80 ± 0.98^{bcd}	36.20 ± 2.26^{k}
Roma zaria 1	28.00 ± 1.41^{h}	61.00 ± 5.65^{cd}	9.50 ± 0.70^{bcd}	14.40 ± 1.13^{bc}	45.90 ± 0.84^{ij}
Roma zaria 2	36.00 ± 1.41^{e}	41.50 ± 2.12^{i}	8.50 ± 2.12^{cd}	12.35 ± 1.62^{cde}	54.60 ± 1.55^{g}
UTC 02	43.00 ± 2.82^{bc}	48.00 ± 2.82^{fg}	10.00 ± 0.00^{bc}	12.75 ± 1.08^{cd}	211.33 ± 0.00^{a}
UTC 1	38.00 ± 1.41^{d}	53.50 ± 6.36^{ef}	14.00 ± 1.41^{a}	6.95 ± 2.02^{g}	86.58 ± 0.00^{c}
CV	2.59	4.6	9.1	10.38	3.31
F Value	91.6***	66.13***	12.56***	17.09***	810.9***

Key: FW-Fruit width (mm), FL-fruit length (mm), TFW-Thickness of fruit wall (mm), SFWP-Single fruit weight\plant (g), TFWP-Total Fruit weight\plant (g), CV-Coefficient of variation; Means followed by the same letter are not significantly different at 5% level of probability $p < 0.0001$.

Table 3b: Tomato yield parameters.

Samples	TNFP ± SD	PH ± SD	TLA ± SD	TLW ± SD
Dan India (Zamfara)	16.50 ± 2.12^{bcd}	61.50 ± 2.82^{efg}	5.65 ± 0.21^{ii}	2.35 ± 0.07^{gh}
Dan Nassarawa	19.50 ± 0.70^{bc}	59.00 ± 2.12^{efg}	5.85 ± 0.35^{ih}	2.60 ± 0.14^{fgh}
Dan indian	7.50 ± 3.53^{efg}	60.00 ± 1.41^{efg}	8.10 ± 0.28^{dd}	2.80 ± 0.14^{def}
Derica oblong	8.00 ± 2.82^{efg}	90.75 ± 1.06^{ab}	9.85 ± 0.21^{bb}	3.45 ± 0.21^{ab}
Derica round	3.50 ± 2.12^{fg}	98.50 ± 2.12^{aa}	10.00 ± 0.00^{bb}	3.50 ± 0.14^{ab}
Derica small	20.50 ± 4.94^{bc}	53.05 ± 5.72^{fg}	7.30 ± 0.14^{ee}	3.25 ± 0.21^{bc}
Derica sweet	10.00 ± 4.24^{def}	74.75 ± 0.35^{cd}	7.30 ± 0.14^{ee}	3.10 ± 0.14^{bcde}
Kaduna tangino	6.50 ± 2.12 ^{efg}	90.25 ± 1.06^{ab}	7.40 ± 0.14^{ee}	2.75 ± 0.21^{efg}
Kano tangino	2.00 ± 1.41^{gg}	84.50 ± 0.70^{bc}	8.85 ± 0.21^{cc}	3.20 ± 0.42^{bcd}
Mai Mara	18.50 ± 3.53^{bc}	66.00 ± 2.12^{def}	6.20 ± 0.98 ^{gh}	1.85 ± 0.07^{ii}
Nassarawa dan kasa	19.50 ± 0.70^{bc}	53.50 ± 2.82^{fg}	7.15 ± 0.91^{ef}	2.30 ± 0.14^{hh}
Nassarawaroma 1	22.00 ± 5.65^{bb}	55.30 ± 1.69^{fg}	6.65 ± 0.21^{fg}	2.75 ± 0.21^{efg}
Nassarawaroma 2	20.50 ± 0.70^{bc}	63.55 ± 8.55^{defg}	6.30 ± 0.56 ^{gh}	2.45 ± 0.49^{fgh}
Niger roma 1	13.00 ± 1.41^{cde}	52.50 ± 4.24^{gg}	8.30 ± 0.56^{cd}	2.30 ± 0.28^{hh}
Niger roma 2	16.50 ± 0.70^{bcd}	64.50 ± 8.48^{defg}	5.85 ± 0.63 ^{ih}	1.85 ± 0.07^{ii}
Roma zaria 1	23.00 ± 12.72^{bb}	70.00 ± 0.70^{de}	8.60 ± 0.14^{cd}	2.45 ± 0.07^{fgh}
Roma zaria 2	16.00 ± 2.82^{bcd}	55.50 ± 16.97^{fg}	6.40 ± 0.14^{gh}	2.70 ± 0.28^{efgh}
UTC 02	30.00 ± 2.82^{aa}	64.50 ± 0.70^{defg}	10.75 ± 0.35^{aa}	3.85 ± 0.21^{aa}
UTC 1	19.00 ± 1.41^{bc}	71.00 ± 1.41^{de}	8.00 ± 0.28	2.85 ± 0.21^{cdef}
CV	20.46	7.95	3.57	6.71
F Value	10.98***	13.37***	60.86***	17.05***

Key: TNFP-Total no of fruit\plant, PH-Plant height (cm), TLA-Terminal leaf area (cm), Terminal leaf width (cm), CV-Coefficient of variation; ***-Level of significance at $p < 0.0001$.

Table 3a and 2b above describes the mean and Standard Deviation (SD) for yield parameters of the different morphological characters studied which includes the fruit width, fruit length, thickness of the fruit wall, single fruit weight per plant and the total fruit weight per plant. The variety with the highest fruit width was Kaduna Tangino (46.00) while the lowest was found in Nassarawa roma1 (24.50). Dan India (98.50) and Kano tangino (37.50) had the highest and lowest values for fruit length respectively. The thickness of the fruit wall had UTC 1 and Kano Tangino having 14.00 as the varieties with the highest thickness of the fruit wall while Nassarawaroma 2 had the lowest value at 4.00. On the part of the varieties with the single fruit weight per plant, Derica sweet had 15.79 to clinch the highest while Dan Indian had the lowest value for variety with the least single fruit weight per plant at 4.96. UTC02 and Kano Tangino had the highest and lowest values of 211.33 and 19.89 respectively for total fruit weight per plant. UTC1 for thickness of fruit wall, Derica round for Single fruit weight\plant and Plant height. UTC2 for had the highest values for total no of fruit\plant, Total Fruit, weight\plant, terminal leaf area, terminal leaf width.

Mohammed et al. [34] also had similar findings of significant differences for all the traits they studied. They reported positive and significant association of tomato fruit yield per plant with plant height, number of branches per plant and leaf length shows that taller plants, bearing more branches and longer leaves tend to yield higher as compared to shorter plants. This may be explained by the greater photosynthetic products available for partitioning assimilates to tomato fruit production. Positive and significant association of number of fruits per plant with number of fruits per inflorescence is an indication of increased number of fruits with increased number of fruit bearing inflorescence. Weight per fruit which is a function of fruit size had predictably positive and significant correlation with fruit length and fruit diameter [34].

Mohanty [35] had reported positive and significant correlation of number of fruits per plant with fruit size and single fruit weight. It has been reported that more branching varieties of tomato tend to flower and mature late as shown in the negative and significant association of number of branches per plant with days to flower, days to fruit ripening and days to maturity. This may be due to the fact that much time is spent by the plant in growing more vegetative branches, hence extending its lifespan. Therefore, a breeder interested in improvement for early maturity in tomato may select plants with a smaller number of branches. This study emphasized the importance of morphology in plant characterization and conservation. The varieties investigated in this study possess characters that could be of interest to plant breeders. They are highly marketable because of the characteristics of their fruits portraying a possible linkage between the fruit and vegetable industries and future research

efforts on these plant materials spread across Northern Nigeria. Till date, these resources have not been given any conservation attention and are only held by traditional farmers. This requires attention to enhance future utilization. The need for conservation of these resources and knowledge to complement and balance utilization is crucial. The summary of the morphological investigation showed that Kaduna Tangino could be recommended for fruit width, Dan India for fruit length, UTC 1 for thickness of the fruit wall, Derica sweet is recommended for single fruit weight per plant while UTC02 is recommended for total fruit weight per plant. The characteristics of the fruit of the tomato varieties have been highlighted in this study as key descriptors of tomato [35].

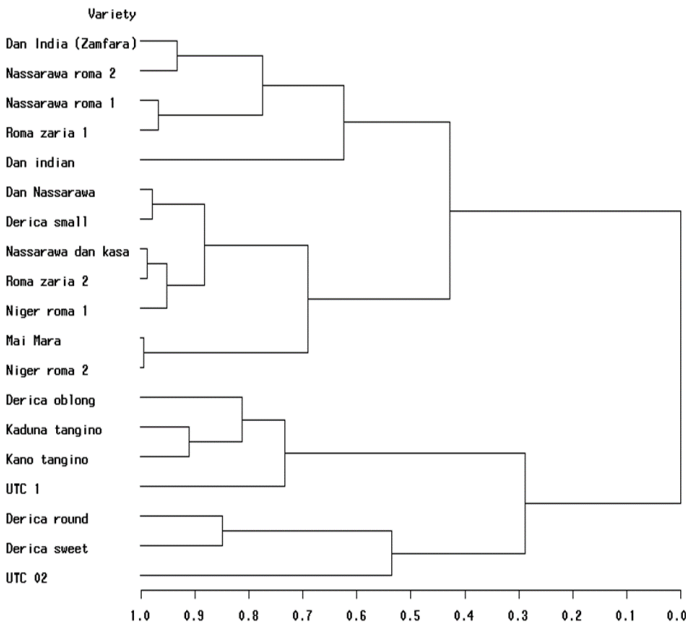

Figure 3: Dendrogram showing the genetic diversity within 19 tomato samples through agro-morphological traits.

Agro-morphological dendrogram result showed all 19 samples of tomatoes distinct at 100% similarity coefficient but at lower similarity index there were 4 clusters without any recourse to the different sampling locations. Cluster I comprise of UTC 02, Derica sweet and Derica round. Cluster II contained UTC1, Kano Tangino, Kaduna Tangino and Derica Oblong. Cluster III contained Niger roma1, Mai mara, Niger roma 2, Nassarawa dan kasa, Derica small and Dan Nassarawa while Cluster IV contained Dan India, Roma Zaria 1, Nassarawa Roma 1, Nassarawa Roma 2 and Dan India (Zamfara). These groupings also correspond to the lycopene, mineral and proximate composition of the samples.

Morphological evaluations of morpho-agronomic characters of tomato germplasms were conducted. Genetic variability, as reflected by the morpho-agronomic characters is the basis of crop breeding on which selection depends to evolve superior genotypes; therefore, the higher the variation expressed for a character in the breeding material, greater is the scope for its improvement through selection [30]. Characterization of tomato germplasms is very important for the work of current and future agronomists and genetic improvement specialists. Characterization therefore aids the documentation of the genetic variability existing in a population. Variation is an important attribute of breeding programs. Morphological traits are important diagnostic features that can be used for distinguishing genotypes [36]. The characters assessed in this study are listed in the International Board for Plant Genetic Resources (IBPGR) as key characters for the crop, and results obtained from this study suggest these may be exploited in the nineteen tomato varieties for tomato breeding in Nigeria and other parts of the world. A considerable proportion of Nigerian farmers practice traditional agriculture, are knowledgeable about plant resources with potentially useful agronomic characters and also aware big/large sizes are better than smaller ones [37]. Genetic diversity can be estimated using measurements of morphological attributes. This is a simple technique for quantifying genetic variation and assessing genotype performance under appropriate growing environments [38]. In a similar study by Nwosu et al. [29] reported that the analysis of variance for the means of all the measured attributes showed significant differences ($p< 0.001$) among the accessions. The precise, fast and reliable identification of important plant varieties is essential in agriculture and plant breeding purposes [39]. Clustering of accessions used in this study into four classic fruit groups corresponding to varietal types was similar to the results of Kwon et al. [40] who characterized 63 tomato varieties of Korea using SSR markers and morphological descriptors. Hu et al. [41] also reported that fruit shape had the most variable types (seven). The 19 accessions used for this study also provides differences in the morphological traits investigated. However, molecular characterization using SSR markers would further provide additional details on the results obtained. Highly significant differences among the varieties for all attributes measured is an indication of enough genetic variability and diversity of the varieties hence the scope for improvement of this crop. Similar observations have been reported on 14 characters [42].

Conclusion

The present study provides evidence that morphological variations exist among the 19 tomato samples studies and could provide further support for targeted breeding programmes.

References

1. FAO. “State of Food and Agriculture 2013: Food Systems for Better Nutrition,” ESA/FAO. 2014.
2. Bello OB, Habib U, Olawuyi O, et al. Microorganisms causing post-harvest tomato (Solanum lycopersicum L.) fruit decay in Nigeria. Scientia. 2016; 13: 93-96.
3. Birgen J. Effects of stages of maturity on the susceptibility of tomato fruits to postharvest fungal pathogens. 2015; 5: 140-147.
4. Aidoo R, Danfoku RA, Mensah JO. Determinants of postharvest losses in tomato production in the Offinso North district of Ghana. Journal of development and agricultural economics. 2014; 6: 338-344.
5. Owureku-Asare M, Ambrose RK, Oduro I, et al. Consumer knowledge, preference, and perceived quality of dried tomato products in Ghana. Food Science & Nutrition. 2017; 5: 617-624.
6. Anthon GE, Diaz JV, Barrett DM. Changes in pectins and product consistency during the concentration of tomato juice to paste. Journal of agricultural and food chemistry. 2008; 56: 7100-7105.
7. Lavelli V, Kerr W, Sri Harsha P. Phytochemical stability in dried tomato pulp and peel as affected by moisture properties. Journal of agricultural and food chemistry. 2013; 61: 700-707.
8. Olaniran O, Ojo O, Odelade K. Survey of the post harvest diseases and aflatoxin contamination of marketed orange fruit (Citrus sp.) in major cities in Oyo State, Nigeria. Journal of Agriculture and Veterinary Science. 2014; 7: 27-31.

9. Olaniyi J, Akanbi W, Adejumo T, et al. Growth, fruit yield and nutritional quality of tomato varieties. African Journal of Food Science. 2010; 4: 398-402.

10. Yazici S, Yanar Y, Karaman I. Evaluation of bacteria for biological control of early blightdisease of tomato. African Journal of Biotechnology. 2011; 10: 1573-1577.

11. Mwangi MW, Monda EO, Okoth SA, et al. Inoculation of tomato seedlings with Trichoderma harzianum and arbuscular mycorrhizal fungi and their effect on growth and control of wilt in tomato seedlings. Brazilian journal of Microbiology. 2011; 42: 508-513.

12. Shi J, Wang X, Sun C, et al. Studies on antifungal activities of myristica oil against pathogenic fungal strains on postharvest tomato. Storage and Process. 2013; 13: 28-32.

13. Snowdon A. Post-harvest diseases and disorders of fruits and vegetables: Volume 2: Vegetables. Manson Publishing Ltd. London, UK. 2010.

14. Lolas M, Moggia C, Chacon F. Harvest Maturity, Packaging and Storage Time Related to Calyx-End Rot Expression on Packham's Triumph Pears Under Refrigerated Storage. In "VII International Symposium on Pear Growing 475". 1997; pp :459-470.

15. Xu XM, Robinson J. Effects of fruit maturity and wetness on the infection of apple fruit by Neonectria galligena. Plant Pathology. 2010; 59: 542-547.

16. Zhu Z, Zhang X. Effect of harpin on control of postharvest decay and resistant responses of tomato fruit. Postharvest Biology and Technology. 2016; 112: 241-246.

17. Barkai-Golan R. "Postharvest diseases of fruits and vegetables: development and control," Elsevier. 2001.

18. El-Rafai IM, Asswah SM, Awdalla OA. Biocontrol of some tomato disease using some antagonistic microorganisms. Pakistan Journal of Biological Sciences (Pakistan). 2003; 3: 39-40.

19. Niknejad Kazempour M, Sharifi-Tehrani A, Okhovat M. Effect of antagonistic fungi Trichoderma spp. on the control of fusarium wilt of tomato caused Fusarium oxysporum f. sp. lycopersici under greenhouse conditions. Iranian Journal of Agricultural Sciences. 2000; 31: 31-37.

20. Oliveri C, Scalone D, Muratore G, et al. " Innovation and enhancement of almond processing chain", a project to highlight the almond dried fruit quality in Sicily (South Italy). In "II International Symposium on Discovery and Development of Innovative Strategies for Postharvest Disease Management 1053". 2013; pp:133-139.

21. Wani A. An overview of the fungal rot of tomato. Mycopath. 2011; 9: 33-38.

22. Abd_Allah EF, Hashem A, Al-Huqail A. Biologically-based strategies to reduce postharvest losses of tomato. African Journal of Biotechnology. 2011; 10: 6040-6044.

23. Janisiewicz WJ. Biocontrol of postharvest diseases of temperate fruits. Plant-microbe interactions and biological control. 1998; 171-198.

24. Lurie S, Fallik E, Handros A, et al. The possible involvement of peroxidase in resistance toBotrytis cinereain heat treated tomato fruit. Physiological and Molecular Plant Pathology. 1997; 50: 141-149.

25. Tanksley SD, Fulton TM. Dissecting quantitative trait variation-examples from the tomato. Euphytica. 2007; 154: 365-370.

26. Khan TN, Ramzan A, Jillani G, et al. Morphological performance of peas (Pisum sativum) genotypes under rainfed conditions of Potowar region. J. Agric. Res. 2013; 51:51-60.

27. Akinfasoye J, Dotun A, Ogunniyan J, et al. Phenotypic relationship among agronomic characters of commercial tomato (Lycopersicum esculentum) hybrids. American-Eurasian Journal of Agronomy. 2011; 4: 17-22.

28. Hu X, Zhang Y, Shi Y, et al. Effect of exogenous spermidine on polyamine content and metabolism in tomato exposed to salinity–alkalinity mixed stress. Plant Physiology and Biochemistry. 2012b; 57: 200-209.

29. Nwosu D, Onakoya O, Okere A, et al. Genetic variability and correlations in rainfed tomato (Solanum spp.) accessions in Ibadan, Nigeria. Greener J. Agric. Sci. 2014; 4:211-219.

30. Chime AO, Aiwansoba RO, Osawaru M E,et al. Morphological Evaluationof Tomato (Solanum lycopersicumLinn.) Cultivars. Makara Journal of Science. 2017; 21: 7.

31. Omotoso S, Aluko M. Cowpea (Vigna unguiculata (L) Walp.) Performance and yield as influenced by soil types and phosphorus fertilizer in two alfisols at Ado-Ekiti, south-West, Nigeria. Journal of Agriculture, Forestry and the Social Sciences. 2016; 14: 71-79.

32. Salim MMR, Rashid MH, Hossain MM, et al. Morphological characterization of tomato (Solanum lycopersicum L.) genotypes. Journal of the Saudi Society of Agricultural Sciences. 2020; 19: 233-240.

33. Fiorani F, Schurr U. Future scenarios for plant phenotyping. Annual review of plant biology. 2013; 64: 267-291.

34. Mohammed S, Abdurrahman A, Attahiru M. Proximate analysis and total lycopene content of some tomato cultivars obtained from Kano State, Nigeria. ChemSearch Journal. 2017; 8: 64-69.

35. Mohanty B. Variability, heritability, correlation and path coefficient studies in tomato. Haryana Journal of Horticultural Sciences. 2002; 31:230-233.

36. Hammer K, Arrowsmith N, Gladis T. Agrobiodiversity with emphasis on plant genetic resources. Naturwissenschaften. 2003; 90: 241-250.

37. Meijer S S, Catacutan D, Ajayi OC, et al. The role of knowledge, attitudes and perceptions in the uptake of agricultural and agroforestry innovations among smallholder farmers in sub-Saharan Africa. International Journal of Agricultural Sustainability. 2015; 13: 40-54.

38. Fu X, Ning G, Gao L, et al. Genetic diversity of Dianthus accessions as assessed using two molecular marker systems (SRAPs and ISSRs) and morphological traits. Scientia horticulturae. 2008; 117: 263-270.

39. Ashraf M, Foolad MR. Crop breeding for salt tolerance in the era of molecular markers and marker-assisted selection. Plant Breeding. 2013; 132: 10-20.

40. Kwon YS, Park SG, Yi SI. Assessment of genetic variation among commercial tomato (Solanum lycopersicum L) varieties using SSR markers and morphological characteristics. Genes & Genomics. 2009; 31: 1-10.

41. Hu X, Wang H, Chen J, et al. Genetic diversity of Argentina tomato varieties revealed by morphological traits, simple sequence repeat, and single nucleotide polymorphism markers. Pakistan Journal of Botany. 2012a; 44: 485-492.

42. Mahmood T. Path coefficient analysis of yield component in tomato (Lycopersicon esculentum). Pak J Bot. 2008; 40: 627-635.