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Eco-geographic Distribution of Tomato (*Solanum lycopersicon* l.) Landraces in Tanzania: Implications for Conservation and Sustainable use of Plant Genetic Resources

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ABSTRACT

Solanum lycopersicon L. is one of the most important and widely grown vegetable crops in Tanzania accounting for 51 % of the total fruit and vegetable production. Tomato landraces are known to provide genes for the breeding programs. Despite this, loss of landraces due to introduction of improved cultivars threatens future use of these resources hence calling for efforts for their collection and conservation. In this study, field exploration, data and germplasm collection were carried out in 44 villages of seven regions in Tanzania. The results shows differential distribution and diversity of tomato landraces between altitudes and regions. The plant appears to be more abundant in mid altitudes compared to the low and high altitudes. Most importantly, the plants were reported to have important attributes such as drought and insect pests and diseases resistance, and the ability to grow without agrochemical inputs.

Keywords: Tomato landraces, eco-geographic distribution, ex situ conservation

INTRODUCTION

Tomato (*Solanum lycopersicon* L.) of the *solanaceae* family is one of the most important and widely grown vegetable crop in the world (1). The species is native to the Andean region in the western South America and was introduced in Tanzania some years back, though the exactly year of introduction is yet to be known (2). To date, the species has been naturalized to the local conditions in many places in Tanzania where some plants are found in the wild as escapee from the fields. The species has about 8 wild species which belongs to the *esculentum* and *peruvianum* complexes (3). The cultivated tomato species (*S. lycopersicon*) is believed to have evolved from its wild progenitor *S. lycopersicon* (2).

Tomato is beleaved to have high nutritive values, good taste and multiple uses (1). In Tanzania, tomato accounting to 51 % of the total fruits and vegetables produced in the country. Large volume of tomato produced in Tanzania finds its market in Kenya with an estimated cross border annual volume 16,000,000 kg valued at Tshs. 6.0 billion. Furthermore, tomato landraces are potentially very important genetic resources for provision of new sources of genes for use in breeding programs (4; 5; 6; 2; 7). These resources have been selected and their genes introgressed into selected materials to create tomato lines for the development of modern varieties with multiple traits (8; 9). Another potential use of local varieties lie on their good flavor and their ability to grow with little need of agrochemical inputs, this has recently promoted the demand of the local varieties among the communities globally (10; 11; 9).

Apart from its potential, loss of local varieties (landraces) due to the introduction of improved cultivars has been a most common phenomenon (9). The collection and conservation of horticultural genetic resources is an important undertaking to ensure their long term availability though the named undertaking have limitedly find its way in Tanzania (12). This calls for an intensive eco-geographic survey to locate their distribution and areas with potential germplasm for collection and conservation. This paper provides information on the eco-geographic distribution of tomato landraces in Tanzania for generation of sampling strategies, germplasm collection and use.

MATERIALS AND METHODS

Tomato Landraces Field Exploration, Data and Germplasm Collection

A synthesis of tomato landrace distribution and diversity in Tanzania was based on the field exploration, data and germplasm collection carried out between April to June 2012 in 44 villages from twelve districts in seven regions in Tanzania (Table 1). The study involved a multistage sampling whereby tomato landraces distribution information available at the National Plant Genetic Resources Centre, in Arusha, Tanzania was reviewed. The areas predicted to have a large number of Tomato landraces were identified. Semi structured interviews were carried out with the district authorities (District Agricultural and Livestock Development officers (DALDO) to identify the study villages which represented the available agroecological zones of the study districts. In each village, key informants were randomly sampled with the assistance of village leaders (13).

Farmers were interviewed about the landraces they maintain (seed origin, ancientness, uses, features of tomato cropping systems), the named information were entered into a special collection form developed by the SADC Plant Genetic resources Centre (SPGRC). The number of tomato plants per sampling population (accessions) was counted and the ripe tomato fruits collected using cotton bags.

Geographic coordinates and elevation data were collected for each sample collected using a hand held Geographic Position System (GPS).

Table1. *Distribution of the tomato landraces study and collection sites in Tanzania*

Zone	Region	District	Number of villages
SOUTHERN HIGHLANDS	Iringa	Kilolo	3
		Iringa rural	1
	Njombe	Ludewa	7
	Ruvuma	Songea rural	5
		Namtumbo	3
	Mbeya	Rungwe	1
		Kyela	3
LAKE	Kagera	Bukoba	12
WESTERN	Kigoma	Kigoma rural	3
		Kigoma ujiji	1
		Uvinza	2
CENTRAL	Singida	Singida rural	3

Data Analysis

Geographic Distribution and Spatial Analysis of Tomato Landraces

The geographic and passport data generated were entered into an eco-geographic data base (Conspectus) in Microsoft excel program (14). Each individual landrace represented a geo-referenced observation known as present point which includes the basic passport data of an individual landrace in specific geographic area (15). All the geo-referenced observations were imported into DIVA – GIS program for the distribution mapping and spatial analysis (16).

Tomato Landrace Diversity and Distribution Across The Administrative Regions and the Altitudes

DIVA – GIS was used to estimate landraces diversity based on Shannon (H'), Simpson (D), Mergaleaf (DMG) indices and Richness estimators (Abundance and evenness) Jacknife -1 (16). The analysis focused on the study of diversity at landrace level (Unit of alpha diversity) as modified from Magurran (17).

Table2. *Diversity indices*

Index	Formula
Margalef	$D_{mg} = (S - 1) / \text{in}(N)$
Shannon	$H' = -\sum p_i \text{ in } p_i$
Simpson	$D = (\text{in } N_i - \sum \text{in } n_i) / N$
Jacknife 1	$S_{jack1} = S_{obs} + Q_1(m - 1/m)$

Where: S is the number of unique classes per cell; N is the number of observations per cell; n_i is the number of individuals in the i^{th} class and p_i is the proportional abundance of the i^{th} class (= ni/N), Sob is the total number of landraces observed in all samples pooled; Qi is the number of landraces occurs in exactly j samples (q1 is the frequency of unique, Q2 the frequency of duplicates, m is the total number of samples.

The landraces were grouped into their respective geographic regions and percentage distribution calculated. Tomato accessions were categorized into altitudinal classes with relative resemblance of agro-climatic origin using formula:

$K=1+3.32\log_{10} n$ and $W=(L-S)/K$ according to Agrawal (18).

Where:

K = number of class intervals, W =width of class intervals, L= the largest value, S= the smallest value and n= sample size (in this case the number of accessions).

The habitats of tomato landraces and collection sources were extracted from the collection forms and frequency distribution and percentages calculated. Further, the information on the attributes of each sample was generated from the collection forms.

RESULTS AND DISCUSSIONS

The Geographic Distribution and Diversity of Tomato Landraces in Tanzania

Figure 1 shows the distribution of tomato landraces in the seven regions in Tanzania.

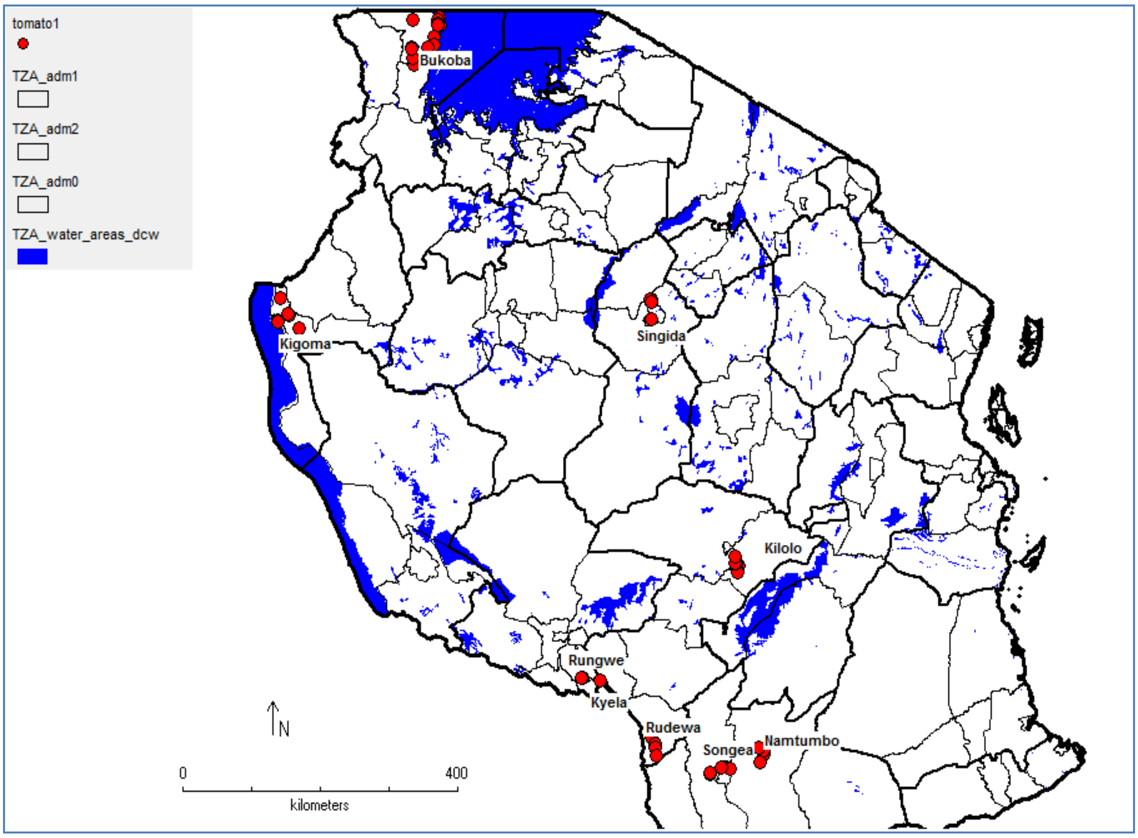

Figure1. *A map of Tanzania Showing the distribution of Tomato landraces collection*

A total of 96 tomato landrace accessions were collected in the seven regions visited, processed and conserved at the national gene bank in Tanzania. The largest number of landraces were collected in Kagera region (26), followed by Ruvuma (19), Singida and Kigoma, while very small number were collected from Mbeya (6), Iringa (9) and Njombe (10). The number of samples (accessions) collected per region ranges from 1 - 8, data shows a great variation in the accessions collected per region, ranging from 1 – 3 in Iringa to 1 – 8 in Singida. This is evident also from the average samples collected per region. The smallest average was collected in Njombe and Mbeya (1.428 and 1.5 respectively). Regardless of largest number of landraces collected in Kagera region (27 %), the average number per sites was very small (2). The findings indicated high abundancy of tomato landraces in Kagera region compared to the rest however, were not evenly distributed across the study sites due to large number of farmers in Kagera maintaining tomato landraces in small numbers compared to other regions.

Table3. *Distribution of tomato landrace accessions in the seven collection regions in Tanzania*

Region	Number of landraces per site[a]		Percentage of landraces
	Range[b]	Average[c]	
Iringa	1 – 3	2.25 (9)	9
Njombe	1 – 4	1.428 (10)	10
Ruvuma	1 – 5	2.37 (19)	20
Mbeya	1 – 3	1.5 (6)	6
Singida	1 – 8	4.33 (13)	14
Kigoma	1 – 3	2.166 (13)	14
Kagera	1 – 4	2.166 (26)	27

[a] The collection sites represent the villages where the landraces were collected

[b] Range = Maximum number of samples – Minimum number of samples collected per region

c Average Total number of landraces per region (in parentheses)

Abundances of the Tomato Landrace Populations/ Accessions in the Study Regions

The number of individual plants per sampling units (population/ accessions) was generally very small with an average of 1.0289 and varied greatly between the study sites (Table 4). Iringa region had the largest number of plants per sampling unit ranging from 1 – 6 (average of 3.55) followed by Ruvuma, 1 – 5 (average of 1.78), while in Kagera regardless of the largest number of populations/ accessions collected, the populations in the area had the least number of plants (1 – 2 at an average of 1.038). The findings is in conformity with fact that tomato landraces in most of the study area in Tanzania grows on their own through seed dispersal by birds or manure transportation to the fields and in very rare cases farmers raise few seedlings for planting. Farmers reported to maintain few plants they found on their farms or near their houses for domestic uses.

Table4. *Distribution of individual plants in the sampling unit/ accessions in the study area*

Region		Number of plants per sample (accessions)	Percentages
	Range[a]	Average[b]	
Iringa	1 – 6	3.55(32)	20
Njombe	1 – 4	1.9(19)	12
Ruvuma	1 – 5	1.78(34)	22
Mbeya	1 – 4	1.83(11)	7
Singida	1 – 3	1.38(18)	11
Kigoma	1 – 3	1.30(17)	11
Kagera	1 – 2	1.03(27)	17

[a] Range = Maximum number of plants – Minimum number of plants collected per region

[b] Average and the total number of plants per region (in parentheses)

Diversity Analysis based on DIVA GIS

Table 5 indicates the diversity of tomato landraces among the seven study regions based o four indices (Mergalef, Shannon, Simpson and Jacknife -1). The Mergalef, and Simpson richness estimators indicated high landrace richness in Singida while the rest of the regions had the same richnesses. While Shannon index estimated high landrace richness in Njombe and Ruvuma followed by Singida while the rest had similar diversities. On the other hand Jacknife -1 (the indicator of evenness) showed high landrace evenness in Singida and more similar for the rest (Table 5). The estimates are similar with the distribution analysis in table 3 which regardless of large total number of samples collected in Kagera, their average were very low (2) compared to Singida (average of 4.33). Therefore, for conservation purposes, Singida, Njombe and Ruvuma can be regarded as high priority area for tomato landraces collection.

Table5. *Diversity of tomato landrace accessions in the seven collection regions in Tanzania*

Region	Diversity indices			
	Mergalef	**Shannon**	**Simpson**	**Jack – 1**
Iringa	0.0000 – 0.0805	0.0000 – 0.1323	0.0000 - 0.0333	0 – 1
Njombe	0.0000 – 0.0805	0.5293 – 1.0000	0.0000 - 0.0333	0 – 1
Ruvuma	0.0000 – 0.0805	0.5293 – 1.0000	0.0000 - 0.0333	0 – 1
Mbeya	0.0000 – 0.0805	0.0000 – 0.1323	0.0000 - 0.0333	0 – 1
Singida	0.3219 – 1.0000	0.1323 – 0.2646	0.1333 – 1.0000	2 – 3
Kigoma	0.0000 – 0.0805	0.0000 – 0.1323	0.0000 - 0.0333	0 – 1
Kagera	0.0000 – 0.0805	0.0000 – 0.1323	0.0000 - 0.0333	0 – 1

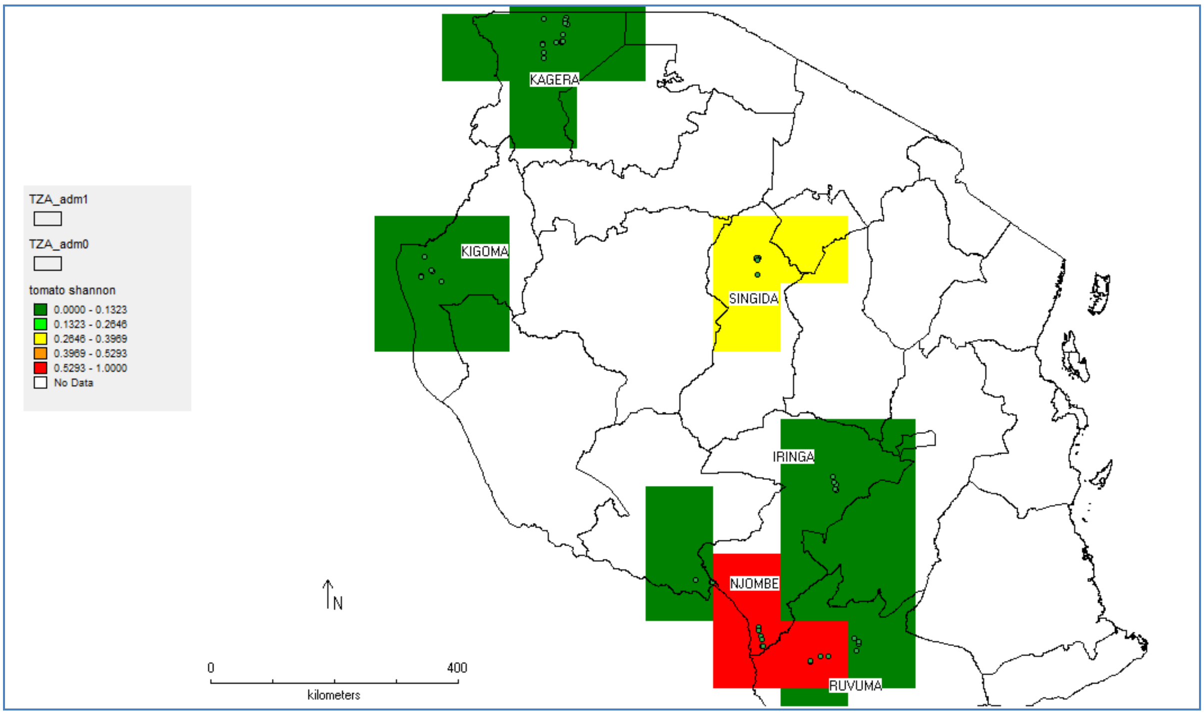

Figure2. *Tomato landraces diversity based on Shannon index in Tanzania*

Altitudinal Ranges of Tomato Landraces in the Seven Regions in Tanzania

The collected tomato landraces falls into eight altitudinal classes from 446 – 1798 meters above sea level (Fig 3). The largest number of landraces were collected in the altitudes ranging from 1219 - 1411 masl (26 %) followed by 833 – 1025 masl (21 %), while the smallest numbers was collected in the altitudes between 1605 – 1797 masl (9 %) and 446 – 639 masl (3%). (Fig. 3)

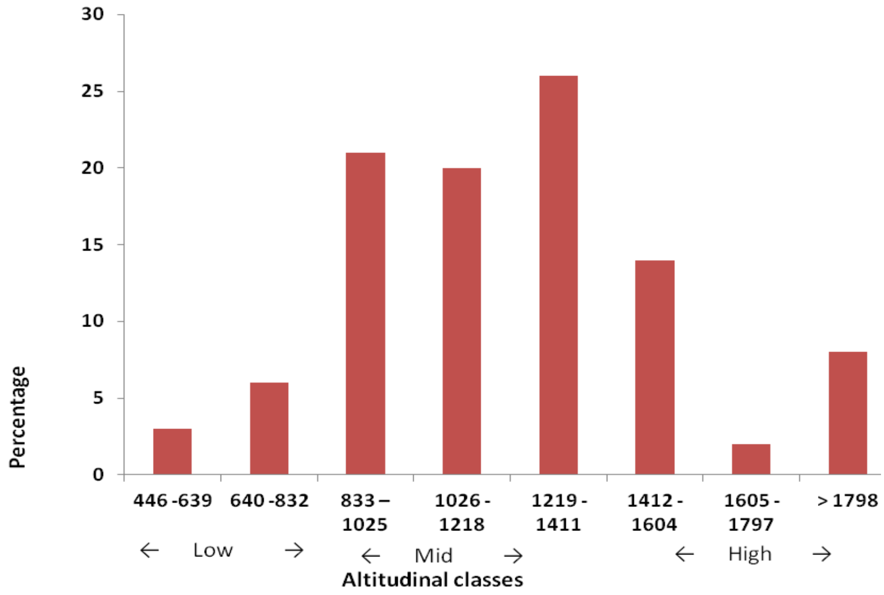

Figure3. *Altitudinal distribution of tomato landraces collected in seven regions in Tanzania*

The altitudinal classes were then categorized into three altitudinal groups (Fig. 3); Low (446 – 832), mid (833 – 1411) and high (1412 – >1798). Based on this grouping, high tomato landraces diversity was found on the mid altitudes (67%), followed by high altitudes (24%), while the low altitude class had the least diversity (9 %).

The Habitats of Tomato Landraces in the Collection Sites

The tomato landraces in the seven regions were found in three habitat types. Over half of the landraces (54 %) were found in the homestead (backyards) associated with garden plants such as the amaranth and cucurbits, 40 % were found on the farmlands associated with the annual and perennial crops and 6 % were found in abandoned fields and fallows. In both habitats, tomato landraces usually grow on their own and dispersed by birds and sometimes by farmers when carry farmyard manures to their farms. In rare cases, farmers do raise the seedlings for planting.

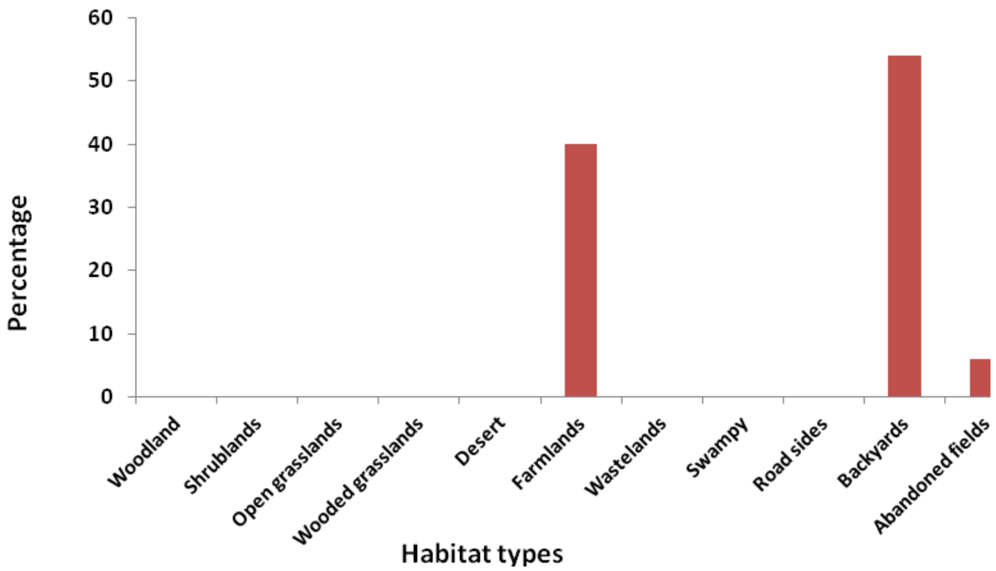

Figure4. *Description of tomato landraces habitat in the seven study regions*

Useful Attributed of the Tomato Landraces

Farmers described tomato landraces as drought tolerance, delicacy/ good taste, insect pests resistant, they are grown without fertilizers and pesticides, they are harvested for a long time (takes longer to expire) and are intercropped with other crops. The fruits are consumed locally and sometimes sold to the local markets, though the market still not very big especially in villages. The plant is used mainly as food and medicinal some cased local communities use it as color for writing and painting. The named observations by farmers in the selected areas of Tanzania corresponds to other report (9), expressing farmers preference on tomato landraces due to their flavor and organic in nature.

CONCLUSION AND RECOMMENDATIONS

Crop landraces have been described as potential genetic resources with due respect in crop improvements. Tomato landraces in particular have a great potential following discovery of useful genes such as for insect pests resistance, also attributes like drought tolerance makes the crop to be of high value as far as crop improvements is concerned. To date there has been an increased demand of these resources due to their cultivation without the use of fertilizer and pesticides as well as its delicacy. However, its market in most of the rural areas is still very low. The information presented herein has demonstrated the presence of tomato landraces throughout the study regions at different magnitudes. In most cases they were found in small numbers both interms of the accessions and the number of plants per accessions. The plant appears to be more abundant in mid altitudes compared to the low and high altitudes. Most importantly, the plants were reported to be highly useful due to their unique properties such as drought and insect pests and diseases resistance, and their ability to grow organically (without fertilizers and pesticides.

Therefore, it is recommended that contented effort should be devoted to their collection and conservation under the ex situ condition for their future use.

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REFERENCES

[1] Zeshan, M. A., M. A. Khan., S. Ali. and M. Arshad. 2016. Phenotypic evaluation of Tomato Germplasm for the source of resistance against tomato leaf curl virus disease. The Journal of Animal and Plant Sciences 26(1):194 – 200.

[2] Spooner, D. M., I. E. Peralta. and S. Knapp. 2005. Comparison of AFLPs with other markers for phylogenetic inference in wild tomatoes (*Solanum* L. section *Lycopersicon* (Mill.) Wettst.). TAXON 54(1): 43 – 61.

[3] Bay, Y., C. C. Huang., R. D. Hulst., F. M. Dekens., G. Bonnema., P. Lindhourt. 2003. QTLs for Tomato Powdery Mildew Resistance (*Oidium lycopersic*) in *Lycopersicon parviflorum* G1.1601 Co-localize with two Qualitative Powdery mildew Resistance Genes. Mol. Pl. Micr. Inter. Vol. 16 (2): 169 – 176.

[4] Esquinas Alcazar, J. T. 1981. Genetic resources of tomato and wild relatives. Rep. Inter. Board Pl. Genet. Res. No. AGP. IBPGRI – 08 – 103, International Board for Plant Genetic Resources, Rome.

[5] Rick, C. M. 1982. The potential of exotic germplasm for tomato improvement. Pp. 1 – 28 in Vasil, I. K., W. R. Scowcroft and K. J. Frey (eds). Plant Improvement and Somatic Cell Genetics. Academic Press, New York.

[6] Stevens, M. A. and C. M. Rick. 1986. Genetics and breeding. Pp. 35 – 109 in: Atherton, J. G and J. Rudish (eds). The Tomato Crop: A Scientific Basis for Improvement. Chapman and Hall. London.

[7] Foolad, M. R. and L. Zhang. 2015. A Recombinant Inbred Line Population of Tomato and its Genetic Map Construction Based on a *Solanum lycopersicon* x *S. pimpinellifolium* Cross. Advanced Studies in Biology vol. 7 (11): 441 – 471.

[8] Diez, M. J. and F. Nuez. 2008. Tomato. In Prohens J., Nuez F (eds). Handbook of plant breeding: vegetables II. Springer, New York.

[9] Figas, M. R., J. Prohens., M. D. Raigon., P. Fernandez-de-Cordova., A. Fita., S. Soler. 2015. Characterization of a collection of local varieties of tomato (*Solanum lycopersicon* L.) using conventional descriptors and the high – throughput phenomic tool Tomato Analyzer. Gen. Res. Crop Evol . 62: 189 – 204.

[10] Brugalolas, M., L. Martinez-Carrasco., A. Martinez-Poveda., J. J. Ruiz. 2009. A competitive strategy for vegetable products: traditional varieties of tomato in the local market. Spanish J. Agric. Res. 7: 294- 304.

[11] Causse, M., V. Saliba-Colombani., L. Lecomte., P. Duffe., P. Rousselle, and B. Buret. 2010. Analysis of Fruit Quality in Fresh Market Tomato: A few Chromosome Regions Control the Variation of Sensory and Instrumental Traits. J. Exp. Bot. 53 (2002), 2089 – 98.

[12] Swai, R. E. A. 1991. Genetic Resources of Horticultural Crops in Tanzania. In: Shao, F. M.,F. S.Magingo., A. N. Minjas., H. F. Bitanyi and R.L. Mahunnah (eds). Proc. of the first National Workshop on Plant Genetic Resources and Biotechnology. Benedictine Publicaions, Ndanda, Peramiho, Tanzania.

[13] Grum, M., Gyasi, E. A., Osei, C., Kranjac-Berisavljevic, G. 2008. Evaluation of best practices for landrace conservation.: Farmer evaluation. Bioversity International, Rome, Italy. 20pp.

[14] Guarino, L., N. Maxted., E. A. Chiwona. 2005. Ecogeography of Crops. IPGRI Technical Bulletin No. 9. International Plant Genetic Resources Institute, Rome, Italy.

[15] Alercia, A., S. Diulgheroff., T. Metz. 2001. FAO/IPGRI Multi-crop Passport Descriptors. Bioversity International, Rome.

[16] Hijmans, R. J., L. Guarino., M. Cruz., E. Rojas. 2001. Computer tools for spatial analysis of plant genetic resources data: 1. DIVA – GIS. Plant Genetic Resources Newsletter No. 127: 15 – 19.

[17] Margurran, A. 1988. Ecological Diversity and its Measurements. Princeton University Press, Princeton, New Jersey.

[18] Agrawal, B. L. 1996. Basic statistics. 3rd Edn. New Age International Limited, New Delhi. Pp. 713.

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