PLANT BREEDERS ASSOCIATION OF NIGERIA
HYBRID ANNUAL CONFERENCE, MAKURDI 2023
(ISSN: 3027-088X)

VARIABILITY STUDIES AMONG SOME ACCESSIONS OF TOMATO (*SOLANUM LYCOPERSICUM* L.) IN MUBI, ADAMAWA STATE

Ochigbo, A. E.
Department of Plant Breeding and Seed Science,
Joseph Sarwuan Tarka University, Makurdi.

Jonah, P. M.
Department of Crop Science, Faculty of Agriculture,
Adamawa State University, Mubi. Nigeria

Aliyu, B
Department of Agronomy, Taraba State University, Jalingo, Nigeria

Correspondence: ochigboene2016@gmail.com:

Abstract
Field experiments were conducted during 2021 and 2022 rainy season, to evaluate the genetic variability among 10 tomato accessions in Adamawa State University Research Farm, Mubi, Adamawa State and to determine difference in pattern of variations among the tomato accessions; also, to identify and select the most promising accession of tomato among the accessions studied. The experiments were laid out in a Complete Randomized Block Design replicated three times. Twelve quantitative traits collected included: days to first and 50% flowering, plant height, leaves/plant, branches/plant, stem girth, fruits/plant, leaf width and length, clusters/plant, fruits/plant and fruit yield. Seventeen qualitative traits were measured which include, plant growth type, stem pubescence density, stem internode length, leaf attitude, leaf type, color of immature fruit, fruit pubescence, predominant fruit shape, fruit size, color of mature fruit, depression at peduncle end, fruit shape at blossom end. Other traits are, fruit shape in longitudinal section, peduncle abscission layer, fruit detachment from pedicel, fruit cross-sectional shape and seed color. Results revealed highly significant difference for all characters studied except stem girth that showed a non-significant difference. Similarly, 14 out of the 17 qualitative traits studied revealed a remarkable distinction of variation. ADSUM/001, ADSUM/003, ADSUM/005, and ADSUM/006 outperformed the other accessions with respect to earliness, plant height, branches/plant, clusters/plant, leaves/plant and stem girth.

Keywords: Variability, Quantitative and Qualitative characters, Accessions and Tomato

Introducton
Tomato (*Solanum lycopersicum* L.) is an edible fruiting plant often grouped as vegetable (Godia, 2014) and the crop comes from the *solanaceae* family (Youdeowci, 2004). Tomato comprises of other species such as tobacco, peppers, eggplant and potato. Tomato originated from South America but is currently found all over the world (Hokche *et al.,* 2008). The Portuguese introduced tomato into West African sub–region between 16th and 17th century (Osei *et al*., 2013) and it is an important vegetable crop widely cultivated for human consumption. The vegetable growers can grow tomato on a small scale in the home garden, where a few plants yield fruit for the whole family and in commercial scales as a cash crop (Mylavarapu and Kennelly, 2002). In 2008, approximately 130,000,000 tons of fresh fruit of tomato were produced globally (FAO, 2013; Godia, 2014). Idah *et al.* (2007) reported that tomato is cultivated annually in Nigeria with an annual production of six Million tonnes. Tomato accounts for 15% of the world vegetable production (FAO, 2013) with China, India, United States of America, Turkey, Egypt,

Iran, Brazil, Spain, as the major producers. Production in Nigeria has more than double in the last ten years, with the production in 2013, amounting to about 879, 000 tonnes (Akanbi and Oludemi, 2013).

The edible fruit of tomato plant has a series of usages in different forms. The crop is nutritious and contain high amount of dietary source of vitamins A, B, C, E and nicotinic acid (Osei *et al.,* 2010; Godia, 2014). Its cultivation provides source of employment to many and continue to play a key horticultural role in terms of reducing poverty and food security (Osei *et al.*, 2014). According to Kaushik *et al*. (2011), tomato has therapeutic values and used for blood decontamination and cure of gastrointestinal disease. Beside tomato's nutritive and medicinal values, the crop is known as an excellent produce for both indigenous and foreign markets and provides a way out of poverty for small holder growers. Tomato is an excellent source of vitamins, minerals and a rich source of lycopene anti-oxidant that moderates the threats of prostate cancer (Antonio *et al*., 2004; FAOSTAT, 2010).

Areas of production of tomato in Nigeria include most states of Northern Nigeria especially Bauchi, Borno, Kaduna, Plateau, Sokoto and some Southern states of Delta, Kwara and Oyo (Denton and Swarup, 1993). Worthy to note that the production of tomato crop is essentially restricted to the Northern Guinea and the Sudan Savannah ecologies due to favorable climatic conditions, particularly high temperature and low relative humidity.

The magnitude of genetic variability present in a base population of any crop species is pivotal to crop improvement which must be exploited by plant breeders for yield improvement (Idahosa *et al*., 2010). Tomato adaptation to fit many diverse uses is a reflection of the great wealth of genetic variability that exists in the genus *Solanum*, which can be exploited in applied breeding programme (Tigchelaar, 1986). Systematic study and evaluation of tomato germplasm is of great importance for current and future agronomic and genetic improvement of the crop. Inheritance of quantitative traits is often influenced by variation in other traits which may be due to pleotropic or genetic link. Genetic variation assessment is one of the pre- requirements for successful breeding strategies of the crop plant (Teczopoulos and Beheli, 2008).

Basavaraj *et al.* (2010) recorded high significant difference among tomato genotypes with respect to all the characters (fruit weight, plant height, clusters/plant, number of branches/plant, leaves/plant, fruit yield/plant) under studied.

Nwosu *et al.* (2014), research work on genetic variability and correlation studies in tomato revealed highly significant differences among 19 accessions for all the traits studied: number of days to flowering, days to 50% flowering, plant height, branches/plant, fruit length and diameter and fruits yield/ plant.

Das *et al.* (2018) trial on 16 characters of 20 tomato genotypes revealed a wide range of variation in plant height, equatorial diameter, polar diameter, pericarp thickness, locule number, primary branches, fruits/plant, fruit weight and fruit yield/plant.

Eighteen genotypes of tomato were evaluated by Arya *et al.* (2018) showed genetic variability in plant height, fruit weight, fruit length, fruit diameter number of fruits/plant and fruit set among other traits studied.

Statement of Problems

There has not been any breeding work on tomato in the Northern Guinea Savannah of Nigeria especially in Mubi environment. Regardless of government efforts that include establishment of a number of tomato processing factories, the right quality and quantity of tomato for commercial agro-processing are not being grown. Many farmers plant local varieties, characteristically low yielding, susceptibility to pest and diseases, poor shelf life, high water content, many seeds, poor color, and low brix against the increasing demand at local and international level (Elisabeth and Sashi, 2010).

In order to overcome these challenges, the development of high yielding tomato genotypes through evaluation and selection of accessions with good horticultural characteristics and making recommendation for their inclusion into breeding programme for yield improvement cannot be over-emphasized. This study, therefore, sought to study genetic variations and to assess the early generations of ten tomato accession for yield and yield components in Northern Guinea savannah ecological zone of Nigeria. Moreover, crop improvement programme require that desired traits are heritable which direct or aid the breeder to determine at what stage of the breeding programme meaningful selection are to be practiced. In this context, the present investigation was carried out to unravel the components of genetic variability among 12 quantitative and 17 qualitative traits of tomato accessions.

Materials and Methods

Experimental Site

The study was conducted at Food and Agricultural Organization/Tree Crop Plantation (FAO/TCP) of Crop Science Department, Adamawa State University Mubi, during 2021 and 2022 rainy seasons.

Ten tomato accessions were used for this study, of which eight of the accessions were sourced from National Center for Genetic Resources and Biotechnology (NACGRAB) Ibadan, and two accessions were sourced locally from open market, as shown in Table 1.

Nursery Operation

Ten raised nursery beds 45cm × 45cm and 1m apart were prepared at FAO/TCP Farm, Department of Crop Science, Adamawa State University, Mubi. 1 kg of poultry droppings were spread on each bed and allowed to decompose for two weeks. Fresh poultry droppings were avoided since they contain high ammonia, which is capable of killing the tomato seedlings. The seeds of each of the ten accessions were sown by broadcast method on each of the raised seed bed. After germination, thinning was done to avoid overcrowding of the seedlings. All nursery management activities were carried out and the nursery operation lasted for four weeks, after which transplanting was done.

Transplanting of Tomato Seedlings

The seedlings were transplanted when they were four weeks old on already ploughed and harrowed field at the FAO/TCP Farm, Adamawa State University, Mubi. Transplanting was done in the early morning, after a light shower of rainfall. The plants were spaced at 60cm × 60cm, making a total of 16 plants per plot.

The experimental field used measured 24.5m × 8m (196 m^2). The field was ploughed; after which it was harrowed to obtain a pulverized soil. Hand hoe was used for land leveling to obtain fine soil tilt for easy penetration of seedlings during transplanting. Sixteen seedlings of each accession were transplanted per plot, in a Randomized Complete Block Design (RCBD) with three replications. A total of 10 plots (i.e. ten treatments) constituted a replicate and the ten tomato accessions were randomly allocated to each plot.

Pest and Diseases control and Weeding

In controlling possible incidence of pests and diseases associated with tomato, Cypermetrin was applied weekly during flowering and fruiting stages. Hand hoe was used to control weeds at 3 and 6 weeks after transplanting (WAT), to a weed free plots. The application of fertilizer (NPK 20:10:10) was done to boast the nutrient of the soil and the application was done using the spot method, at a spot distance of 5 cm from each tomato stand at 6 WAT and 9 WAT.

Staking of Tomato Plants

This was done using sticks to support the tomato plants in order to prevent them from having contact with the soil, so as to prevent the fruits from rot. Staking was done at flower initiation, whereby stakes of 1 m long were used. The stakes were pegged into the soil and the tomato vines were trailed on the stakes using twine. The purpose of the stake is to provide each plant the ability to grow without bending to the point where it will break.

Data Collection

Data was collected on twelve agronomic parameters from eight tagged plants in the net plot: days to first and 50% flowering, plant height (cm), branches/plant, number of clusters/plant, leaves/plant, number of fruits/cluster, leaf length and leaf width, stem girth, fruits/plant and fruit yield (t/ha).

Seventeen qualitative characters were collected using UPOV Guidelines, (2001) and IPGRI Descriptor, (1996) are as follows: plant growth type, stem pubescence density, stem internode length, leaf attitude, leaf type, exterior color of immature fruit, fruit pubescence, predominant fruit shape, fruit size, exterior color of mature fruit, depression at peduncle end and fruits blossom end shape. Other qualitative characters measured include: fruit shape in longitudinal section, peduncle abscission layer, easiness of fruit to detach from its pedicel, fruit cross-sectional shape and seed color.

Statistical Analysis

The data on agronomic traits were subjected to analysis of variance (ANOVA) using Minitab Computer Software Program and means that were significant using F test ($P \leq 0.05$) were separated using Duncan Multiple Range Test.

Estimation of Genetic Parameters

The genetic parameters were calculated using Burton and Davane (1953), Singh and Chaudhary (1985) method.

Genetic variance $\delta^2_g = \frac{MSg - MSe}{r}$

Phenotypic Variance $\delta^2_p = \sigma^2_g + \sigma^2_e$

Variance due to error = MS_e

Where

MS_g and MS_e are genotype and error mean square and r = number of replications

Results and Discussion

Analysis of Variance for Agronomic Characters of Tomato

The combined analysis of variance for 12 agronomic characters of tomato cultivated across years is presented in Table 2. Highly significant difference ($p<0.01$) was observed among the accessions for the flowering traits, plant height, number of branches/plant, number of clusters/plant, number of leaves/plant, number of fruits/cluster, leaf length and width, fruits/plant and fruit yield but a non-significant difference was recorded for only plant stem girth. Similarly, the accession x Year interaction revealed highly significant difference for most characters studied except for branches/plant, number of fruits/cluster, leaf width and plant stem girth. The significant differences observed for the flowering traits, (days to first and 5% flowering), including the other ten characters studied provided evidence of genetic variability among the tomato accessions evaluated. These indicate that the accessions had wide genetic variability, which implies that selection among these accessions could aid in tomato genetic improvement. Wide genetic variability results in tomato were earlier reported by some researchers (Shankar *et al.,* 2013; Osekita and Ademuluyi*,* 2014; Nwosu *et al.,* 2014; Oduor 2016; Das *et al.,* 2018; Tsagaye and Alemu 2021).

Mean Performance of 12 Agronomic Characters of Tomato Studied

The mean performance of 12 agronomic characters of tomato Studied is shown in Table 3. The results showed that early maturing accessions for days to first flowering and days to 50% flowering were ADSUM/003 and ADSUM/006. For days to first and 50% flowering, the results further showed that accession 10 (Seeriya) which recorded 45.83 and 48.67 days was a late maturing genotype. This accession was significantly different from the other accessions. ADSUM/005 had the tallest plants (76.43 cm), followed by ADSUM/003(74.9 cm) and then ADSUM/004 that had 72.31 cm, although these accessions were statistically similar. ADSUM/010 (Seeriya) had the least plant height (57.09 cm). Accession 3 (ADSUM/003) had the highest number of branches/plant (13.62), followed by ADSUM/010and ADSUM/009 with 13.53 and 13.45 branches/plant respectively. These three accessions statistically were at par. The least number of branches/plant was recorded by ADSUM/002 (7.88). For number of clusters/plant, ADSUM/001 recorded 7.88 clusters followed by ADSUM/003 with 7.47 clusters, while ADSUM/009 was the least.For number of leaves/plant accession ADSUM/003 gave the highest number of leaves (96.5), followed by accession ADSUM/005 (65.83) and then ADSUM/006 with about 62 leaves/plant. For number of fruits/cluster, ADSUM/002 (5.62) was the most superior, followed by ADSUM/001 with 5.22 fruits/cluster and the least estimates was recorded by ADSUM/006.ADSUM/009 (improved variety) gave the longest leaf length (25.73 cm), followed by ADSUM/006 (24.75 cm) and the least leaf length was recorded by ADSUM/003 (21.6 cm). In a similar vein, ADSUM/009had the longest leaf width of 17.65 cm, followed by ADSUM/010 (17.27 cm) and the least was ADSUM/003 with 12.39 cm. For stem girth character recorded a non-significant difference among the ten accessions evaluated. Furthermore, for number of fruits/plant accession 3 (ADSUM/003), had 126.53 fruits and it was statistically different from the other accessions, followed by ADSUM/001 with 62.48 and the lowest fruit number was recorded by ADSUM/005. For fruit yield (t/ha) ADSUM/001 (10.45t/ha) outweighed all the other accessions. This was followed by ADSUM/007 with 10.41 t/ha and then ADSUM/008 with 10.30 t/ha. These three accessions were statistically similar with respect to tomato fruit yield while ADSUM/009 had the least fruit yield (6.36 t/ha).

The comparative performance of the ten accessions of tomato revealed a clear agronomic superiority of some of the accessions. Great potential for improvement exist for two accessions (ADSUM/003 and ADSUM/006), which flowered earlier than the other accessions and also performed better for plant height, branches/plant, cluster/plant, number of leaves/plant and stem girth. Accession 10, though late maturing excelled in most of the agronomic characters (branches/plant, clusters/plant, leaves/plant, leaf length and width including stem girth). High yielding accession included ADSUM/001, ADSUM/007, ADSUM/008 and ADSUM/005). Depending on the breeding objective, there is a wide range of accession to choose. For instance, if the breeding objective is to produce high yielding varieties, then these four accessions could be useful for the hybridization approach with any of the early maturing genotypes that are low fruit yielders. Worthy to note that earliness in growth as earlier reported (Ofori *et al.,* 2005; Dhankhar and Dhankhar, 2006 and Effah *et al.,* 2017) is an important trait to select for, especially in areas of less seasonal rainfall especially in Northern Guinea Savanna of Nigeria.

Variation in 17 Qualitative Characters of Tomato

Variation in fourteen qualitative characters of tomato are summarized in frequency distribution (Table 4).From the table all the accessions showed 100% in determinate plant growth type and also 100% exterior color of mature fruit (red color fruit) and also all the tomato genotype had abscission layers in their peduncles (ie 100%) Out of the ten accessions studied, seven (70%) of them had dense stem pubescence while three (30%) of the accessions had a sparse pubescence. Sixty percent of the genotype had short stem internode length and forty percent had intermediate internode length. For leaf attitude traits, two of the accessions (20%) were semi erect, forty percent each of the accessions were dropping and horizontal.

Two different leaf types were observed in the accessions of which 90% were potato type and 10% were standard type. For exterior color of immature fruit, six of the accessions (60%) were greenish white; three of them (30%) were light green while one accession was dark green in color. Sparse fruit pubescence was recorded by nine accessions (90%), while one accession had dense pubescence on the tomato fruit. Out of the ten accessions studied, fourdistinctness was observed for predominant fruit shape. Out of which 40% of the accessions had slightly flattened fruit shape, 30% of the accessions were cylindrical in shape, 20% flattened (oblate) and 10% was high round in shape. For the fruit size, two (20%) of the accessions were small sized, while four (40%) of the accessions had very small size and four (40%) had intermediate fruit size tomato.

For depression at peduncle end, accessions based on this character are divided into four groups: weak, absent (or very weak), strong and medium. Four of the accessions (40%) had absent or very weak depression peduncle, (40%) had medium depression peduncle, while two (20%) accession had strong depression peduncle. Based on the shape at blossom end of the tomato fruits, the ten accessions had four groups: indented to flat type (60%), flat to pointed (20%), pointed blossom fruit end (10%) and indented type (10%). Fruit shape in longitudinal section had 20% of the accessions were flattered type, 30% slightly flattened, 20% were cylindrical, 20% circular and 10% had obovate shape. Twenty percent (20%) of the tomato fruits at harvest detached easily from the plant pedicel, 60% were very difficult to detach, while 20% were intermediate. For the cross-sectional shape of fruits trait, 40% showed irregular shape, 40% had round cross-sectional shape, while 20% had angular shape. Furthermore, from the ten accessions studied, 40% revealed light yellow seed color, 50% had dark yellow seed color and. 10% grey seed color.

From the studies, six accessions had short stem internode and four of them had intermediate internode length for the leaf types which corroborates the findings of Grandillo *et al.* (1999) and Quaid (2017), who reported that nine of their tomato accessions were potato type and one had standard leaf type. Quaid (2017), earlier reported variation in leaf types of eighteen tomatos genotype of which six of the accessions showed greenish white. Furthermore, for the exterior color of immature fruit, that revealed three were light green and one dark green color, agrees with the findings of Quaid, (2017).

Four distinctness was observed for predominant fruit shape of which four of the accessions had slightly flattened fruit shape, three accessions were cylindrical, two flattered, and one round in shape also agreed with the finding of Quaid, (2017). The seventeen qualitative characters studied revealed a remarkable distinction of variation for the qualitative traits except for plant growth type, exterior color of matured fruit and peduncle abscission layer.

Conclusion

The study showed that ADSUM/001, ADSUM/003, ADSUM/005 and ADSUM/006 performed better than the other tomato accessions for early flowering, plant height, branches/plant, clusters/plant leaves/plant stem girth traits. The highest tomato fruit yielders were ADSUM/001 (10.45 t/ha), ADSUM/007 (10.41 t/ha), ADSUM/008 (10.30 t/ha) and ADSUM/005 (9.94 t/ha). Therefore, possible exploitation of these accessions for the improvement of tomato could be carried out through multi-location trials for several years to ascertain results obtained in this study. The accessions ADSUM/001, ADSUM/003, ADSUM/005 and ADSUM/006 could be cultivated by farmers in drought areas, since they performed better than the other accessions for earliness, and most agronomic traits. Tomato accessions ADSUM/001, ADSUM/007, ADSUM/008 and ADSUM/005 could be cultivated by farmers who desire high yielding cultivars in Mubi environs.

References

Akanbi, C. T. and Oludemi, F. O. (2013). Effect of Processing and Packaging on the Lycopene Content of Tomato Product. *International Journal of Food Production,* 7: 139-151.

Antonio, I., Nigro, F. and Schenna, I. (2004*). Control of Post-Harvest Disease of Fresh Vegetable by Application of Antagonistic Micro-organisms.* Randanediris; Raina, N. and Shr, M., Crop Management and Post-Harvest Handling of Horticultural Products, Pp 1-3.

Arya, W. R., Achinad, C., Muchanad., Syukur, A. and Maharijiya, S. (2018). Short Communication: Genetic Variability, Heritability, Correlation and Path Analysis in Tom*ato (*Solanum lycopersicum*) Under Shading Condition, *Biodervesitas,* 19(4): 1527-1531.

Burton, G. W. and Dave, E. M, (1953). Estimating Heritability in Fall Feschele (*Festuca arunelinaceia*) From Replicated Clonal Material. *Agronomy Journal,* (45): 478-481.

Basavaraj, S. N., Hosamani, R. M. and Patil, B. C. (2010). Genetic Variability in Tomato (*Solanun lycopersicon* wattsd.). *Karnatuka Journal of Agricultural Science,* 23(3): 536-537.

Das, B., Murmur, D. K., Ghimiray, T. S., Krafoma, J., Kundu, S. and Yonzone, R. (2018) Estimate of Genetic Variability and Characters Association of Fruit Yield and Quantity Fruit in Tomato. *International Journal of Pure Applied Bioscience.* 6(1):1587-1595.

Denton, O. A. and Swarup, V. (1983). Tomato Cultivation and its Path Analysis in Tomato Under Normal and High Temperature Condition. *Haryana Journal of Horticultural Science,* 30 (1-2): 89-92.

Dhankhar, S. K .and Dhankhar, S. S. (2006). Variability, Heritability, Correlation and Path Coefficient Studied in Tomato. *Journal of Horticulture*, 35(1 & 2): 179-181.

Effah, Z., Oseh, M.K., Akumah, R. and Prinmpong, M. (2017). Hybridization Between Cherry Tomato (small fry) Petomech for Shortened Fruit Maturation, Size and Earliness. *African Crop Science Journal* 25(1): 25-32.

Elizabeth, R. J. Z. and Shashi, L. K. (2010). The Case of Tomato in Ghana: *Processing. Working Paper* 21. Accra, Ghana: International Food Program. International Food Policy Research Institute (IFPRI)-ACCRA.

FAO (2013). Food and Agricultural Organization, https://www.fao.org.foastat.

FAOSTAT. (2010). Food and Agricultural Commodities Production; Available www.faostat.fao.org (Assessed 21 July 2012).

Godia, A. K. G. (2014). Evaluation of Some Introduced Fresh Market Tomato *(Solanum lycopersicum L.*) For Genetic Variability and Adaptability in Ghana Using Morphological and Molecular Markers. M.Sc. (Plant Breeding) Kwame Nkrumah University of Science and Technology, Kumasi, Ghana School of Graduate Studies Department of Crop and Soil Sciences.

Grandillo, S., K. U, H. M., and Tanksley, S. D. (1999). Identifying the loci Responsibility for Natural Variation in Fruit and Shape in Tomato. *Theoritical Applied Genetic,* 99: 978-987.

Hokche, O., Berry, P. and Huber, O. (2008). *Neuvo Cat. FL. Vasc, Venezuela:* 1-859 Fundacion Institute Botanico de Venezuela, Caracas.

IPGR [International Plant Genetic Resources Institute] (1996). Disciptor for Tomato (IPGR). Rome Italy, Pp 1 – 46.

Idah, P. A., Ajigiri, E. S. A. and Yisa, M. G. (2007). Fruits and Vegetable Handling and Transportation in Nigeria.*Australia Journal,* 10(3): 175-183.

Idahosa, D. O., Alika, J. E. and Omeregie, A. U. (2010). Genetic Variability, Heritability and Expected Genetic Advances as Indices for Yield and Yield Components Selection in Cowpea (*Vigna unguiculata)* (L.) Walp, *Acamdia Asena*, 2(5): 22-26.

Kaushik, S. K., Tomar, D. S., and Dixit, A. K. (2011). Genetic Fruit Yield and Contributing Characters in Tomato

(*Solanun lycopersicon*) *Journal of Agricultural Biotechnology and Sustainable Development* 3(10):209-213.

Mylavarapu, R. S. and Kennelley, D. E (2002). UF/IFAS Extension Soil Testing Laboratory (ESTL): *Analytical Procedures and Training Manual.* Institute of Food Agriculture Science, University of Florida, Gainesville, U.S.A:28.

Nwosu, D. J., Onakoya, O. A., Okere A.U Babatunde A.O., and Popoola, A. F. (2014).Genetic Variability Tomato (*Solanum spps*.) Accessions in Ibadan. Nigeria. *GreenerJournal of Agricultural Science,*4 (5): 211-219.

Oduor, K. T. (2016). Agro-morphological nutritional characterization of tomato landrace Lycopersicon species in Africa, M.Sc Thesis in Agronomy, University of Nairobi, Pp 1 - 113

Ofori, K., Kumaga, F. K., and Yonyigah, A. (2005). Morphological Characteristics and
Agronomic Activity of Tomato by Increasing the Total anti-Oxidant. *Journal of Agriculture and Food Chemistry,* 145: 23-28.

Osei, M. K., Aantem. D., Agyeman, A., Adebayo, M. A., Adu-Dapaah, H. (2014). Plant Breeding: A Tool for Achieving Food Sufficiency: Sustainable Horticultural Systems: Issues, Technology and Innovation, Life Science, Spring Science Business Media B.V. Van Godewijckkstreat 30311 GX Dordrecht the Netherlands, 253-274.

Osei, M. K., Bonus, K. O., Asare, C. M Agyeman, A., Gyau, J. and H. (2013). Germplasm Collections: A Pre-requisite for Tomato Breeding Programme in Ghana. *Advanced Crop Science*, 13(19): 568 – 578.

Osei, M. K., Akromah, R., Shilh, S. L and Green, S. K. (2010). Evaluation of Some Tomato Germplasm for Resistance to Tomato Yellow Leaf Curls Virus Disease (TYLCV) in Ghana. *Aspect Applied Biology*, 96:315 -323.

Osekita, O. S., and Ademiluyi, A. T. (2014). Genetic Advance Heritability and Character Association of Component Yield in Some Genotypes of Tomato *(Lycopersicum Esculetun* Mill Wattsd) Aeasemia *Journal of Biotechnology* 2(1): 006-010.

Quaid, H., Samad N., Ara A., Soharil, S., Hahzad, A. M., and Umir H. (2017). Evaluation of Tomato Accession for Quantitative and Qualitative Traits Under Agronomic Climatic Condition of *Pashwar Research Article,* 6(4)1345-1353.

Shankar, A., Reddy, R. V. S. K., Sujatha, M., and Prata, P. M. (2013). Genetic Variability Studies in F1generation of Tomato (*Solanun lycopersicun* L). *Journal of Agriculture and Vetenary Science,* 4 (5): 31-34.

Singh, B. B. and Chaudhary, B. D. (1985). *Biometic Method in Quantitative Genetic Analysis.* Kalyanti Publishers, Ludhiana, New Delhi, Pp 54 -57.

Terzopoulos, P. J. and Bebeli, P. J. (2008). DNA and Morphological Diversity of Selected Greek Tomato (*Solanum lycopersicun* L) Landrace. *Scientia Horticulture* 116: 354-361.

Tigchelaar, E. (1986). Tomato Breeding in M. J. Basset (Ed). *Breeding Vegetables Crops*, AVI Publishing Company, pp 135-170. Genotype for Quantitative Qualitative & Quality Traits at Mid-attitude and Central Rift Valley. *International Journal in Research in Agricultural Sciences.* 8 (1): 2348 – 3997.

Tsagaye, D. and Alemu, Y. (2021). Evaluation of Tomato (*Solanum lycopersicum* MILL)

UPOV Guidelines (2021). International Union for the Protection of New Variaties of Plants. Guidelines for the conduct of tests, for distinctness, uniformity and stability. Tomato (*Lycopersicon lycopersicum*). Pp 1 – 49.

Youdeowei, A. (2004). *Integrated Pest Management Practices for the Production of Vegetables* CTA/GTA/MOFA-PPRSD.

Table 1: Name and Origin of Tomato Genotypes used for the Experiment

S/No	Genotype Code	Type	Source
1	ADSUM/001	Farmer Variety	Open Market
2	ADSUM/002	Landrace	NACGRAB
3	ADSUM/003	Landrace	NACGRAB
4	ADSUM/004	Landrace	NACGRAB
5	ADSUM/005	Landrace	NACGRAB
6.	ADSUM/006	Landrace	NACGRAB
7	ADSUM/007	Landrace	NACGRAB
8	ADSUM/008	Landrace	NACGRAB
9	ADSUM/009 (improved variety)	Landrace	Open Market
10	ADSUM/010 (Seeriya)	Farmer Variety	Open market

NACGRAB (2018): The National Centre for Genetic Resources and Biotechnology

Table 2: Combined ANOVA for 12 Agronomic Characters in Tomato across Years (2021 and 2022) of Evaluation

Source of Variation	DF	DFF	D50F	PHt	NOB	NOC/Plt	NOL/Plt	NOF/C	LL	LW	PSG	NOF/Plt	FY
Year (Y)	1	98.82**	112.07**	2786.93**	18.82^{ns}	70.85**	13575.10**	0.75^{ns}	0.17^{ns}	45.50**	21.10**	4314.62**	213.01**
Rep (Year)	4	1.83^{ns}	3.57^{ns}	412.96**	2.41^{ns}	12.94**	391.54**	0.18^{ns}	14.03**	0.40^{ns}	3.12^{ns}	709.57**	34.63**
Accession (A)	9	47.71**	48.67**	217.77**	28.53**	6.88**	934.20**	2.80**	9.02**	16.21**	1.32^{ns}	6777.02**	16.10**
A x Y	9	25.82**	10.81**	190.95**	2.43^{ns}	10.56**	252.69**	0.72^{ns}	9.07**	1.12^{ns}	1.46^{ns}	862.13**	5.55^{ns}
Error	36	4.43**	3.25**	91.30**	10.15^{ns}	1.95**	107.62**	0.45**	4.35**	2.66**	1.44**	201.84*	4.39**
Total	59												

* and ** = significant values at $P \leq 0.05$ and $P \leq 0.01$ respectively, DFF = days to first flowering, D50F = days to 50% flowering, PHt = Plant height (cm), NOB = Branches/plant, NOC/Plt = Clusters/plant, NOL/Plt = Leaves /plant, NOF/C = Number of fruits/Cluster , LL = Leaf length (cm), LW = Leaf width (cm), PSG = Plant stem girth, NOF/Plt = Number of fruits/plant and FY = Fruit yield (t/ha).

Table 3: Mean Squares from Combined Analysis (year 2021 and 2022) for 12 Agronomic Characters of Tomato

S/No	Accession Code	DFF	D50F	PHt	NOB	NOC/Plt	NOL/Plt	NOF/C	LL	LW	PSG	NOF/Plt	FY
1	ADSUM/001	37.5^{cd}	43.17^{bc}	$68.04^{a\text{-}c}$	8.43^{b}	7.88^{a}	53.65^{b}	5.22^{ab}	$24.33^{a\text{-}c}$	$16.92^{a\text{-}c}$	11.33^{a}	62.48^{b}	10.45^{a}
2	ADSUM/002	39.83^{bc}	43.33^{bc}	$65.95^{a\text{-}c}$	7.88^{b}	5.52^{C}	56.88^{b}	5.62^{a}	$23.03^{a\text{-}c}$	$15.30^{b\text{-}e}$	11.82^{a}	49.32^{bc}	9.37^{ab}
3	ADSUM/003	36.67^{d}	39.67^{e}	74.9^{a}	13.62^{a}	7.47^{ab}	96.5^{a}	4.7^{bc}	21.6^{c}	12.39^{f}	9.96^{a}	126.53^{a}	$7.80^{a\text{-}c}$
4	ADSUM/004	38.00^{cd}	$42.67^{b\text{-}d}$	72.31^{ab}	9.25^{b}	6.07^{bc}	57.93^{b}	$4.62^{b\text{-}d}$	$23.05^{a\text{-}c}$	13.96^{ef}	10.06^{a}	32.2^{cd}	6.89^{bc}
5	ADSUM/005	37.00^{d}	42.17^{cd}	76.43^{a}	10.15^{ab}	5.65^{bc}	65.83^{b}	5.08^{ab}	$22.98^{a\text{-}c}$	$15.72^{a\text{-}e}$	10.35^{a}	44.43^{c}	9.94^{a}
6	ADSUM/006	37.17^{cd}	40.5^{de}	70.12^{ab}	10.93^{ab}	5.97^{bc}	61.98^{b}	3.57^{e}	24.75^{ab}	$16.55^{a\text{-}d}$	11.04^{a}	20.33^{de}	$7.97^{a\text{-}c}$
7	ADSUM/007	38.83^{cd}	42.83^{bc}	72.46^{ab}	9.82^{ab}	$6.12^{a\text{-}c}$	56.38^{b}	4.95^{ab}	$23.18^{a\text{-}c}$	$15.04^{c\text{-}e}$	10.81^{a}	45.08^{bc}	10.41^{a}
8	ADSUM/008	39.83^{bc}	45.00^{b}	$66.7^{a\text{-}c}$	9.13^{b}	4.73^{c}	58.33^{b}	$3.95^{c\text{-}e}$	22.4^{bc}	14.44^{de}	10.33^{a}	22.75^{de}	10.30^{a}
9	ADSUM/009	41.83^{b}	47.67^{a}	61.44^{bc}	13.45^{a}	4.38^{c}	61.47^{b}	$4.07^{c\text{-}e}$	25.73^{a}	17.65^{a}	10.68^{a}	14.15^{e}	6.36^{c}
10	ADSUM/010	45.83^{a}	48.67^{a}	57.09^{c}	13.53^{a}	$6.15^{a\text{-}c}$	55.62^{b}	3.78^{de}	$24.33^{a\text{-}c}$	17.27^{ab}	11.20^{a}	13.18^{e}	6.81^{bc}

DFF = days to first flowering, D50F = days to 50% flowering, PHt = Plant height (cm), NOB = Branches/plant, NOC/Plt = Clusters/plant, NOL/Plt = Leaves /plant, NOF/C = Number of fruits/Cluster, LL = Leaf length (cm), LW = Leaf width (cm), PSG = Plant stem girth, NOF/Plt = Number of fruits/plant, FY = Fruit yield (t/ha) and ADSUM = Adamawa State University Mubi.

Table 4: Seventeen Qualitative Characters Studied among 10 Tomato Accessions

Accession	PG	SPD	SIL	LA	LT	ECIF	FB	PFS	FS	ECMF	DP	FBS	FSL	PAL	EFDP	FCSS	SC
1	4	7	3	3	3	7	3	2	1	5	3	2	2	9	5	1	1
2	4	7	5	7	2	1	3	6	3	5	1	2	5	9	5	1	1
3	4	7	5	7	2	3	3	6	2	5	1	4	3	9	3	2	2
4	4	3	3	3	2	3	3	2	1	5	3	2	2	9	7	1	1
5	4	3	5	5	2	3	7	6	3	5	3	5	5	9	7	1	2
6	4	3	5	7	2	1	3	1	2	5	1	1	1	9	3	3	2
7	4	7	3	5	2	1	3	2	1	5	4	2	2	9	7	3	2
8	4	7	3	5	2	1	3	2	1	5	3	2	3	9	7	3	3
9	4	7	3	7	2	1	3	4	3	5	1	4	8	9	7	2	1
10	4	7	3	5	2	1	3	1	3	5	4	2	1	9	7	3	2

PG = Plant growth type, (1) dwarf (2) determinate (3) semi determinate (4) indeterminate
SPD = Stem Pubescence Density, (3) sparse, (5) intermediate, (7) dense.
SIL = Stem Internode Length, (3) short, (5) intermediate, (7) long.
LA = Leaf Attitude, (3) semi erect, (5) horizontal, (7) dropping.
LT = Leaf Type, (1) dwarf, (2) potato leaf type, (3) standard, (4) peruvianum.
ECIF = Exterior Color of Immature Fruit, (1) greenish white, (3) light green, (5) green, (7) dark green, (9) very dark green.
FP = Fruit Pubescence, (3) sparse, (5) intermediate, (7) dense.
PFS = Predominat Fruit Shape, (1) flattened (oblate), (2) slightly flattened, (3) rounded, (4) high rounded, (5) heart shaped, (6) cylindrical (long oblong).
FS = Fruit Size, (1) very small, (2) small, (3) intermediate.
ECMF = Exterior Color of Mature Fruit, (1) green, (2) yellow, (3) orange, (4) pink, (5) red.
DP = Depression at Peduncle End, (1) absent or very weak, (2) weak, (3) medium, (4) strong.
FBS = Fruit Shape at Blossom End, (1) indented, (2) indented to flat (3) flat (4) flat to pointed (5) pointed.
FSL = Fruit Shape in Longitudinal Section, (1) flattened, (2) slightly flattened, (3) circular, (4) rectangular (5) cylindrical, (6) elliptic, (7) heart shaped, (8) obovate, (9) ovate (10) pear shaped.
PAL = Peduncle Abscission Layer (1) absent (9) present
EFDP = Easiness of Fruit to Detach from Pedicel, (3) easy, (5) Intermediate, (7) Difficult.
FCSS = Fruit Cross – Sectional Shape, (1) round, (2) angular, (3) Irregular
SC = Seed Colour, (1) Light Yellow, (2) Dark Yellow, (3) Grey, (4) Brown, (5) Dark Brown