2022-08

Variability and participatory evaluation of Tomato (Lycopersicum Esculentum, Mill.) Genotypes for growth, Yield and quality parameters in Kobo District of North Wollo Zone, Amhara Region, Ethiopia

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GRADUATE PROGRAM IN HORTICULTURE

VARIABILITY AND PARTICIPATORY EVALUATION OF TOMATO (Lycopersicum esculentum, Mill.) GENOTYPES FOR GROWTH, YIELD AND QUALITY PARAMETERS IN KOBO DISTRICT OF NORTH WOLLO ZONE, AMHARA REGION, ETHIOPIA

M.Sc. Thesis

By

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July 2022

BAHIR DAR, ETHIOPIA

BAHIR DAR UNIVERSITY

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By:

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Submitted In Partial Fulfillment of the Requirements for the Degree of Master of Science (M.Sc.) In Department of Horticulture

Major Advisor: Dr. Alemu Abate

THESIS APPROVAL SHEET

As member of board of examiner of Master of Science thesis open defense examination we have read and evaluated this thesis prepared by **Mr. Mesfin Kebede Assefa** entitled **"VARIABILITY AND PARTICIPATORY EVALUATION OF TOMATO (*Lycopersicum esculantum*, Mill.) GENOTYPES FOR GROWTH, YIELD AND QUALITY PARAMETERS IN KOBO DISTRICT OF AMHARA REGION, ETHIOPIA".** We here by certify that, the thesis is accepted for fulfilling the requirement of the award of Master of Science (M.Sc.) in **HORTICULTURE.**

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This is to certify that this thesis entitled "**VARIABILITY AND PARTICIPATORY EVALUATION OF TOMATO (*Lycopersicon esculantum* Mill.) GENOTYPES FOR GROWTH, YIELD AND QUALITY PARAMETERS IN KOBO DISTRICT OF AMHARA REGION, ETHIOPIA**" submitted in partial fulfilment of the requirements for the award of the degree of Master of Science (M.Sc.) in **Horticulture** to the Graduate Program of College of Agriculture and Environmental Sciences, Bahir Dar University by **Mr. Mesfin Kebede Assefa** (ID No. BDU 1206743PR) is an authentic work carried out by him under my guidance. The matter embodied in this project work has not been submitted earlier for award of any degree or diploma to the best of my knowledge and belief.

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ACKNOWLEDGEMENTS

First of all, I would like to praise almighty GOD for protecting my life. Second, I would like to express my deepest gratitude to my advisor, Dr. Alemu Abate for his valuable advice, constructive comments and guidance from the time of proposal development up to final write up of the thesis work.

I would like to thank Sirinka Agricultural Research Center, Horticulture department and Melkasa Agricultural Research Center for providing me with seeds of tomato genotypes. I also would like to convey my sincere thanks to the Department of Postharvest, Bahir Dar University, for allowing me to work in their Laboratory. I am indebted to Sirinka Research Center giving me this opportunity to work in the field. I would like to thank Raya Kobo Administration for sponsoring me to pursue my M.Sc. degree in Horticulture.

I would like to express my sincere appreciation to Daniel Mengesha, Mengistu Moges and Zewditu Habtu for their kind facilitation of the work and unreserved help in terms of frequent follow up of the trial. Moreover, appreciations to my brother Molla Kebede, for his absolute help in terms of frequent follow up of the trial and data collection. I also express my special thanks to my friend Fasikaw Belay for his overall guidance and shaping of this research paper.

Finally, many heartfelt thanks also go to my family, particularly to my wife Tiruwerk Zewdu for her special support to the successful completion of this work in particular and for the success in my life in general.

DEDICATION

This piece of thesis work is dedicated to my Father; Kebede Assefa and to my family members for laying great foundation in my life. I also dedicate this thesis to my daughters; Bemnet Mesfin, Bruktawit Mesfin and Amen Mesfin.

LIST OF ABBREVIATIONS AND ACRONYMS

ANOVA	Analysis of Variance
AVRDC	Asian Vegetable Research and Development Center
CEC	Cation Exchange Capacity
CSA	Central Statistic Authority
DAP	Di Ammonium phosphate
DMRT	Duncan's Multiple Range Test
EARO	Ethiopian Agricultural Research Organization
ECV	Environmental Coefficient of Variation
FAOSTAT	Food and Agriculture Organization Statistical Data
GA	Genetic Advance
GAM	Genetic Advance as percent of Means
GCV	Genotypic Coefficient of Variation
GOE	Government of Ethiopia
H^2b	Heritability in broad sense
KGVDPO	Kobo Girana Valley Development Program Office
MARC	Melkasa Agricultural Research Center
MoARD	Ministry of Agriculture and Rural Development
PCV	Phenotypic Coefficient of Variation
pH	Power of Hydrogen
PWL	Physiological Weight Loss
RCBD	Randomized Complete Block Design
RDF	Recommended dose of fertilizer
SAS	Statistical Analysis System
SARC	Sirinka Agriculture Research Center
TA	Titratable Acidity
t/ha	Tons per hectare
TSS	Total Soluble Solid
USA	United States of America

VARIABILITY AND PARTICIPATORY EVALUATION OF TOMATO (*Lycopersicum esculentum*, Mill.) GENOTYPES FOR GROWTH, YIELD AND QUALITY IN KOBO DISTRICT OF AMHARA REGION, ETHIOPIA

By Mesfin Kebede

Advisors: Dr. Alemu Abate

ABSTRACT

Production of tomato in Ethiopia as well as in Amhara Region is low; this could be due to lack of high yielding and high quality genotypes. Therefore, the aim of this study was to evaluate variability and performance of 17 tomato genotypes for growth, yield and quality at SARC Kobo sub center during the 2021 irrigation season. A field experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Analysis of variance for 21 quantitative traits revealed that there was a highly significant difference (P<0.01) among the seventeen genotypes for all the characters studied except unmarketable yield. This indicates the presence of considerable genetic variability for further improvement of tomato for yield and quality aspects. The difference between PCV and GCV was relatively small for most of the traits, implying that genotype contributed more than environment in the expression of the characters. High GCV and PCV was observed for titratable acidity, average single fruit weight, physiological weight loss, plant height and number of cluster per plant. High heritability estimates coupled with high values of genetic advance as percent of mean observed among some traits; indicates that they were governed by additive gene action and therefore provides the most effective condition for selection. Metadel, Woyno, Fetan, and Miya tomato genotypes were matured earlier than the rest of the tested genotypes. Chali (59.62 t/ha), Eshet (51.95 t/ha), Metadel (51.12 t/ha) and Melka salsa (47.43 t/ha) and tomato genotypes gave better marketable fruit yield while Chali, Eshet, Gelila, Metadel, Bishola, and ARP D2 Tomato genotypes had the highest juice content. From the participatory evaluation, Metadel, Chali, Eshet and Cochiro were selected by the farmers. In terms of marketable yield; Chali, Eshet, Metadel, and Melka Salsa genotypes can be recommended for the study area. In terms of fruit quality parameters, the genotypes Chali, Eshet, Gelilal, and Metadel can be suggested for commercial production and processing industry. However, it is advisable to repeat the experiment on different agro-ecologies *and years with more number of materials.*

Keywords: fruit quality, genetic advance, heritability, Juice content, Marketable yield, PCV and GCV, total soluble solid

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Chapter 1: INTRODUCTION

1.1.Background and Justification

Tomato (*Lycopersicum esculantum* Mill.) is one of the most widely consumed vegetable crops in the world. It ranks next to potato with respect to world vegetable production but ranks first as a processing crop (Gemechis Benti *et al*. 2017; Melese Worku and Samul Sahel 2018). It belongs to the genus *Solanum*, family *Solanaceae* (also known as the night shade family), along with other economically important crops such as potato pepper, and eggplant (Jones, 2008; Kelley and Boyhan, 2010).

Tomatoes are extremely beneficial to human health for they are rich in minerals, vitamins, essential amino acids, sugars and dietary fibers. Tomato fruits are consumed fresh in salads or cooked in sauces, soup and meat or fish dishes. They can be processed into purées, juices and ketchup (Naika *et al*., 2005). It is also considered as a protective food because it provides nutrients such as beta-carotene, lycopene, vitamin C (which is important in formation of collagen, a protein that gives structure to bones, cartilage, muscles and blood vessels), vitamin A (which is important for growth, improvement of eyesight and the regulation of immune system and flavonoids. Furthermore, tomato has achieved high popularity especially in recent years because of lycopene's anti-oxidative activities and anti-cancer functions (such as cancers of prostate, lung and stomach) (Fentik, 2017**).**

In 2020, the world's total cultivated area under tomato was 5.05 million ha, with a production quantity of 186.8 million tons (FAOSTAT, 2020). The leading tomato producing countries are China, United States, Turkey, Egypt and India (Anonymous, 2019). China is not only the world's largest fresh tomato producer, but also the world's largest tomato paste producer, followed by the EU and the United States. In 2019, the export quantity reached 818,512 tones, a sharp increase from 106,667 tons in the previous year. Africa contributes 11.8% of total global tomato production (Anonymous, 2019). Within the African continent, tomato is one of the most widely grown vegetables due to its versatility with production cutting across smallholder and commercial farming communities. Trend analysis done in 2014 and 2017 shows that Egypt was still the leading

tomato producer in Africa, followed by Nigeria second (Anonymous, 2019). Production systems differ throughout the continent depending on the agro climates, from greenhouses to open field, with varying levels technological applications.

In Ethiopia, the crop is produced in the range of 700 up to 2200 meter above sea level, with about 700 to over 1400 mm annual rain fall, in different areas and seasons, in different soils, under different weather conditions. In addition, at different levels of technology (e.g. with furrow, drip or spate irrigation) and yields (Birhanu Kebede and Ketema Tilahun, 2010). In Ethiopia, several tomato varieties had been released nationally and recommended by the Melkasa Agricultural Research Center for commercial production and small scale farming systems.

In the year of 2020 of Meher season, the total production of tomato in Ethiopia was about 6.43 thousand hectares with 41.94 thousand tons of harvest (CSA, 2020). However, average yield of tomato in Ethiopia is low, ranging from 6.5-24 t/ ha (Gemechis Ambecha *et al.,* 2017 and CSA, 2020). This is incomparable with average productivity of 16, 96.8, 63.9, 43 and 38.3 tons/ha in Africa, America, Europe, Asia and the entire world, respectively (FAOSTAT, 2019). This may be related to shortage of varieties and recommended package of information, unknown sources and poor quality seeds, poor irrigation system, lack of information on soil fertility, disease and insect pests, high post-harvest loses, lack of awareness of existing improved technologies and poor marketing system(Lemma Dessalegn 2002). According to Dawit Alemu (2008), the productivity of tomato under research and research managed farmers field is about 60 t/ ha.

The improvement of genetic architecture of any crop is determined by the magnitude of genetic differences in a population ready to be taken advantage of and the extent to which the desirable traits are passed from one generation to the other (Tiwari *et al*., 2011). A number of technologies exist and if adopted would improve yield of tomato. One of the key technological components in tomato production is the development of new varieties that are early mature, good quality and high productive, pest and disease, resistant that would contribute to increased yield. Improved new varieties that can resist and tolerate the aforementioned unfavorable factors are among the technologies developed. Successful cultivation of tomato is based essentially upon the choice of suitable varieties for a particular location (Masinde *et al.,* 2011). The farmers choose tomato variety to grow

depending on a number of factors that include production potential, market demand, regional adaptability, pest and disease resistance and the end use of the product (Karuku, *et al*., 2017). Therefore, the present study was planned to evaluate variability and performance of different tomato varieties; to identify high yielding and farmers` preferred varieties.

1.2. Statement of the Problem

Kobo Woreda endowed with beautiful diverse natural resource has the capacity to grow different annual and perennial crops. There is a high potential of ground water resource are of great importance to the Woreda. They are used for irrigation during the dry season mainly for vegetables. Major types of vegetable crops growing in the area include tomato, onion; pepper, cabbage lettuce etc. are produced using furrow and drip irrigation methods throughout the year under small-scale irrigation. The estimated area under production of tomato in the district in 2020/2021 cropping season was 720 ha with total production of 4732 tons of fresh fruit under irrigation (Kobo Wereda Agricultural Office, 2021 report). There is high potential to produce tomato in the district. But due to several reasons, the production is remained low; unavailability of seeds of adapted and improved tomato genotypes, insect-pests, diseases, inadequate knowledge on production and management (processing) systems, poor extension services, poor marketing system and proper utilization of tomato, poor agronomic practices, lack of awareness of existing improved technology and poor postharvest handling.

Among the production constraints, lack of access and awareness to adapted and improved tomato varieties are the most limiting factors. More specifically, at least, performance evaluation of tomato varieties was not done before in the district. In addition, participatory evaluation was not made before on tomato varieties to identify farmers' preferred variety based on their traits of interest. Evaluation of tomato genotypes is very essential to see the performance of genotypes for their adaptability and agronomic performance like growth and yield traits to identify the potential genotype. Participatory variety selection as a desirable method to resolve problems in introduction and adoption of released varieties, in evaluation and selection for preferences of farmers for their target environments. Therefore, the present study was planned to evaluate variability and performance of different tomato varieties; to identify high yielding and farmers` preferred varieties under Raya Kobo district condition.

1.3. Objectives of the Study

1.3.1. General objective

- To contribute for enhanced tomato production and productivity by evaluating genetic variability and performance of tomato genotypes under irrigation condition

1.3.2. The specific objectives:

- To asses variability, heritability and genetic advance of agronomic traits;
- To determine the extent of association among agronomic traits; and
- To identify the best performing and preferred tomato varieties under Kobo conditions

Chapter 2: LITERATURE REVIEW

2.1. Botany of Tomato

Tomato is a dicotyledonous crop with a tap root system. Its stem girth can grow to about 2 to 4cm long (Shankara *et al*., 2013) and has dense lateral and adventitious root (Akinfasoye, 2011).Tomato plants have fragile, hairy and woody stem. Attached to this stem is its compound leaves made of spirally arranged leaflets which are oblong or ovate (Aduhene Chinbuah, 2011). Based on its growing habits tomato plant can be classified as determinate, semi- determinate and indeterminate. Indeterminate plants grow quite tall and typically require staking. Whereas, the determinate type needs no support and stop growing at 1.5m when the flowers form at the terminal growing point (Shankara *et al.,* 2013).

Tomato plant is characterized by its yellow flowers. Its flowers are less than an inch in diameter and can occur in either a simple or a complex inflorescence of about 6 to 12 bisexual flower (Aduhene Chinbuah, 2011). Temperature is one environmental factor that influences the formation of the inflorescence. Agong *et al.* (2001), as well as Shankara *et al.* (2013) indicate that tomato flowers are self-pollinated (autogamous). In some cases, cross-pollination may occur with the aid of pollinators such as wind, insect or animals (Agong *et al.,* 2001; Shankara *et al.,* 2013). The style has a sterile tip, which is elongated, and around the style are six (6) stamen and anthers that are yellow. The stamen and carpals are involved in the reproduction process of the tomato plant. The pollen produced in the stamen fertilizes the carpals. The fertilized ovule then develops into an embryo, which consequently matures to form a seed. The seed is wrapped with flesh within a mature fruit. Tomato has a fleshy fruit and is variable in length, shape and diameter. The fruits are formed from superior ovaries with 2-9 locules.

Karuku (2011) by growth characteristics agree on two types of tomato, determinate and indeterminate. They describe determinate vine growth to mean that the plant will grow a certain amount of foliage and then future growth is directed towards fruit production. Determinate tomatoes include both processing and fresh market types which are smaller in plant size and more compact than the indeterminate type. The plants grow to a certain size,

then produce flowers, and set fruit within a relatively shorter period. This makes it possible to harvest all fruits in a relatively less number of picks (Gruda, 2005). Determinate, or bush, types bear a full crop all at once and top off at a specific height; they are often good choices for container growing.

Indeterminate varieties develop into vines that never stop growing and continue producing until killed by frost. Indeterminate varieties are the best choice for long harvest period because they keep growing after flowering, however, under tropical conditions, diseases and insect attacks may stop the growth. Home growers and local-market farmers who want ripe fruit throughout the season usually grow them (Brandenberger, *et al* 2014). They are also used in field and greenhouse production where high quality fresh fruits are required for salad and where there is adequate annual labour for training the plant and picking the fruits for prolonged periods (Workneh Tilahun *et al*., 2012). The differences in the growth patterns of determinate and indeterminate tomatoes have important implications for agronomic and other management practices. In areas where there is a need for long and continuous harvest for homestead and commercial production, indeterminate fresh market tomatoes are very important (Lemma Desalegn, 2002). The third group is semi-determinate with characteristics between the two types.

2.2. Origin and Distribution Taxonomy of Tomato

The center of origin of tomatoes have been debated by many, some are suggesting the center to be the dry coastal desert of Peru (Jenkins, 1948, Preedy and Watson, 2008, Blanca *et al*., 2012).While others have suggested a dual center with one part in the coastal region between the Andes (Blanca *et al*., 2012) and the ocean and the second part from South Mexico to Guatemala (Bauchet and Mathilde, 2012). Wild relatives of tomato are distributed in the Andes from Ecuador, through Peru and to Chile (Peralta *et al*., 2006), growing between sea level and 3300 meters above sea level (Blanca *et al*., 2012) in diverse climatic conditions. The domestication is still unclear but linguistic evidence has postulated Peru and Mexico as the major regions of domestication (Peralta *et al*., 2006). Tomatoes are known to be used in cooking in Mexico by the Aztecs already 500 BC and were transferred to the rest of the world by the conquistadors after the capture of the Aztecs territory (Bergougnoux, 2014).

Taxonomically, tomato belongs to the Solanaceae family. The cultivated tomato belongs to the species *Solanum Lycopersicum*, while *Solanum pimpinellifolium* is the closest wild relative with a divergence of only 0.6% nucleotide base pairs (Bergougnoux, 2014). The family also includes other important vegetable crops such as potato (*Solanum tuberosum L.*), pepper (*Capsicum spp.* L.), eggplant (*Solanum melongena* L.) and tobacco (*Nicotiana tabacum*). A large variation has been ascribed to the tomatoes as related to differences in shape, color, flavor and other parameters. Wild tomato are generally small as compared with the domesticated ones (Bergougnoux, 2014), and the differences in size is regarded as a result of changes in a total of six quantitative traits loci (QTL) during the domestication process (Bai and Lindhout, 2007, Bergougnoux, 2014).The cultivated tomato was brought to Europe by the Spanish conquistadors in the sixteenth century and later introduced from Europe to southern and eastern Asia, Africa and the Middle East. More recently, wild tomato has been distributed into other parts of South America and Mexico (Zahedi and Ansari, 2012).

2.3. Importance of Tomato

Tomato plays an important role in human nutrition by providing essential amino acids, vitamins and minerals (Sainju *et al.,* 2003). Its vitamin C content is particularly high (Kanyomeka and Shivute, 2005). It also contains lycopene, a very potent antioxidant that may be an important contributor to the prevention of cancers (Agarwal and Rao, 2000). The characteristic red color of tomato results from a combination of Carotenoid pigments, of which lycopene is the most abundant (Bicanic *et al.,* 2003). Lycopene is a natural pigment that imparts red color to tomato, guava, watermelon and pink grapefruit (Holden *et al.,* 1999). Tomatoes, especially deep-red fresh tomato fruits, and tomato products are considered the most important sources of lycopene in human diet. Tomato is rich in medicinal value. The pulp and juice are digestible mild aperients, a promoter of gastric secretion and blood purifier. It is also considered to be intestinal antiseptic (Rai and Yadav, 2005). The acid sweet taste and unique flavors account for its popularity and diverse usage (Balibrea *et al.,* 1997).

Tomato rank first in the relative contribution to human nutrition when compared to 39 major fruits and vegetables (Bourne, 1977). One medium sized tomato provides 40% of the Recommendable Dietary Allowance (RDA) of vitamin C, 20% of the RDA of vitamin A, substantial amount of potassium, dietary fiber, calcium, and lesser amounts of iron, magnesium, thiamine, riboflavin, and niacin, yet it contains only about 35 calories (FAO, 2006). Based on nutrient content and the quantity of tomatoes consumed, they are major contributors of magnesium, thiamine, riboflavin, and niacin to our health (Bourne, 1977).

Economic importance tomato is one of the regional export crops of the country (Chishti *et al*., 2008; Eshed and Zamir, 2008). It serves in various raw and processed materials. Fresh tomatoes are key ingredients in all around the world and processed tomatoes are used to make soup, juice and other products. It is one of the most important and fames vegetables products in the country and most of the time tomato production rural community is one of the sours of income generation crop of rural areas (Naika *et al.*, 2005). The importance of tomato is increasing since it is a high value commodity, and has been given top priority in vegetable research in Ethiopia. Small-scale farmers and commercial growers could grow the crop for its fruits in different regions of the country. It is produced both during the rainy and dry seasons under supplemental irrigation (Lemma Dessalegn, 2002).

2.4. Agro ecological Requirements of Tomato

Even if tomato is warm season crop it can grow under wide range of climate and soil conditions both in the tropics and temperate regions (Gould, 1983), and it is not sensitive to day length and sets fruit in photoperiods ranging from 7–19 hours. Tomato requires clear and dry weather, i.e. warm weather and abundant sunshine for its best growth. At high and low temperatures, there is low germination of seeds, poor plant growth, flower drop, poor seed set and ripening. At high temperature, quality of tomato fruits is poor and there is high incidence of sunscald. Under extreme high and low temperature conditions, the yield and quality of fruits is reduced. For optimal yields, the crop requires plenty of sunshine, moderately cool nights and warm days and well-drained soil. It needs optimum day temperature of 25-28 ℃ and 15-℃ optimum night temperature (Asfaw Zeleke and Eshetu Derso, 2015). Fruit setting is reduced by temperatures that are either low below (13 ℃) or high (above 35℃). Dry winds can also cause flower abortion. Mean temperatures

below 13 ℃ and above 27 ℃ severely impair fruit set and destruction of pollen occurs when the maximum daytime temperature is 38 ℃ or more for 5–10 days. Fruit set is generally poor when night temperatures are above 20 ℃ for a few days both before and after anthesis. Both high and low temperature can adversely affect fruit quality particularly color development (Islam *et al*., 2011). Light intensities below 11,000-lux retard plant growth and delay flowering. Mild winter condition is ideal for seed germination, plant growth, fruit set, fruit development and ripening. An excessive rain adversely affects fruit setting, flower drop, and fruit rotting.

Large-scale tomato production in Ethiopia is mostly during the dry season in the upper awash valley under irrigated because of favorable climatic conditions such as temperature, relative humidity and sunshine (Lemma Dessalegn, 2002). Excessive rainfall or irrigation water supply causes adverse effects on the tomato crop if not staked or mulched due to the spread of fungal diseases (Lemma Dessalegn, 2002). Insufficient water at any growth stage will reduce yield and fruit quality. Rain is another serious factor that affects tomato growth, yield and quality (Weerak kody *et al*., 2001).

Tomato is most sensitive to water deficit during flowering, fruit ripening, somewhat immediately after transplanting and fruit development and least sensitive during vegetative growth. Because indeterminate varieties flower and form fruit continuously, they are always sensitive to water deficits (Geisenberg and Stewart, 1986); Gopalakrishnan, 2007). The plant however requires adequate water supply during its growth period, about 8-10 mm per day during the period of fruit development. Well fertile soil with good moisture retaining capacity and relatively high level of organic matter are best for tomato production. Tomatoes can be grown on many soil types that are well drained. On sandy soil tomato mature early but silt or clay loam soil is generally considered the most productive. Slightly acidic soils with a pH of 5.0 to 6.5 are suitable (Rice *et al*., 1990) with optimal soil pH of 6.0 to 6.5. Tomatoes are considered heavy feeders because of their rapid growth and long production season. Production of one ton of fruit requires large amount of N, P and K fertilizers or it removes large amount of these nutrients from the soil.

2.5. Potentials and Constraints of Tomato Production in Ethiopia

Ethiopia is endowed with abundant agricultural resources and has diverse agro-ecological zones, suitable edaphic and climatic conditions, availability of improved varieties and excessive human labor. Agriculture is the mainstay of the economy(Hunde 2017). The Government of Ethiopia (GOE) has identified key priority intervention areas to increase productivity of smallholder farms and expand large-scale commercial farms. Under the current administration, the GOE has renewed its emphasis to develop the agriculture sector, ensure food security, and achieve import substition. The development of small- and large-scale irrigation systems, as well as the production of fruits and vegetables, are among the GOE's key priorities(Tilahun *et al.,* 2011). In addition, the GOE is looking to the agro-processing sector (also a best prospect sector) as one engine to spur future economic growth. With respect to increasing productivity, the GOE, alongside its international partners, has made a number of interventions to support the development of the agriculture sector. These activities have contributed to higher yields and increased production of both fruits and vegetables. At the same time, to accelerate the country's agricultural development, the government established the Agricultural Transformation Institute (ATI) to address systemic bottlenecks in the agriculture sector by supporting and enhancing the capability of the Ministry of Agriculture (MOA) and other public, private, and non-governmental implementing partners (Alamerie., *et al* 2014).

In addition, some of Ethiopia's cash crops show potential for growth and offer possible investment opportunities in areas such as coffee, oilseeds, pulses, fruits and vegetables, cut flowers, tea, and spices. Most of these crops are exported to generate foreign exchange. In the future, the government intends to work with the private sector to develop capacity to process some of these commodities, like fruits and vegetables, in order to add value and capture higher export prices(Hunde 2017).

The introduction of cultivated tomato in to Ethiopian agriculture dates back to the period between 1935 and 1940. The Ethiopian Institute of Agricultural Research (EIAR) was established in 1966 (Setotaw Ferede, 2006) during which tomato was recognized as a commodity crop. The first record of commercial tomato cultivation is from 1980 with a production area of 80 ha (Lemma Dessalegn, 2002) in the upper Awash by Merti Agro industry for both domestic as well as export markets. The total area increased to 833 ha

by the year 1993 and later on the cultivation spread towards other parts of the country. The climatic and soil conditions of Ethiopia allows the cultivation of a wide range of fruit and vegetable crops including tomato, which is largely grown in the eastern and central parts of the mid-to low-land areas of the country. The crop has been grown between 700 and 2200 meter above sea level having 700 to over 1400 mm annual rain fall in different seasons, under different weather conditions, at different levels of technology and yield (Birhanu Kebede and Ketema Tilahun, 2010). Large scale production of tomato takes place in the upper awash valley under irrigated and rain-fed conditions whereas small scale production for fresh market is a common practice around Koka, Ziway, Wondo-Genet, Guder, Bako and many other areas (Lemma Desalegn, 2002).

Tomato has high economic importance in Ethiopia. In Ethiopia the total areas under tomato crop in the rainy season are estimated to be 6.43 thousand hectares with 41.95 thousand tons of harvest (CSA, 2020). However, average yield of tomato in Ethiopia is low, ranging from 6.5-24 tha^{-1} (Gemechis Ambecha *et al.*, 2017and CSA, 2020). This is incomparable with the average yield of other countries. In Ethiopia, several tomato varieties were released nationally and recommended by the Melkasa Agricultural Research Center and others institutes for both commercial production and small scale farming systems. Varieties such as Melkashola and Marglobe are widely produced.

The production of Tomato is faced with a number of constraints which are biotic and a biotic that resulted into low yield. Biotic factors contributing for lower yield of tomato in Ethiopia include insect pests (Gashaw Beza 2009). Plant parasitic weeds are also one of the factors affecting tomato yield (Etagegnehu Assefa 2009). Drought, heat, and poor cultural practices constitute abiotic factors for lower productivity of tomato (Lemma Dessalegn, 2002). The lack of varieties that are adaptable to different agro-ecologies, poor quality seeds, high post-harvest loss, disease and insect pests, lack of awareness of existing improved technology and poor marketing systems are some of the major constraints associated with tomato production in Ethiopia (Lemma Dessalegn 2002).

2.6. Effects of Varieties on Growth, Yield and Quality of Tomato

A number of factors affect the growth, yield and quality of tomato fruits of which genotypic variability is the most important one (Workneh Tilahun *et al*., 2012). Olaniyi *et*

al, (2010) carried out an experiment where the assessment of seven varieties of tomatoes was done. He evaluated the growth, fruit yield and quality of the varieties. The results showed that DT 97/162 A(R) gave the highest height compared to Ogbomoso local variety. This shows that the yield and the quality of tomato depend on the variety. Ojo *et al*, (2013) assessed the performance of tomato varieties in the Southern Guinea Savanna Ecology of Nigeria. Four varieties of tomato namely Roma Savanna VF (an improved variety), two hybrid varieties and a local variety constituted the treatments. Highly significant variety effect was observed for all the traits.

Olaniyi and Fagbayide (1999) reported that variation in yield may also be due to genetic differences among the varieties since they were grown under the same environmental conditions. Lack of high yielding varieties combined with quality attributes is major constraints in tomato production in the tropics. In a study conducted in Tunisia, range of tomato cultivars were evaluated and concluded that tomatoes are adaptable to organic production (Riahi *et al.,* 2007). The nutrition quality of the tomato fruits depend on variety, state of maturity at harvest, amount of nutrient during growth, environmental stress and water management (Mikkelsen, 2005).

In Ethiopia, several tomato varieties had been released nationally for commercial production and small scale farming systems. According to Dawit Alemu (2008), the productivity of tomato under research and research managed farmers field is about 60 tha^{-1}. In a study conducted in Jimma University, four improved tomato varieties under irrigation in greenhouse and open field condition revealed that varieties Marglobe and Moneymaker in greenhouse showed the highest total fruit yield per plant (Jima University 2014/15 unpublished). In a study conducted in Agaro and Jimma by Jimma Agricultural research center (JARC, 2014/15), ten improved tomato varieties with one local check were evaluated for their yield and yield component and varieties; ARP tomato D2, Cochiro and Fetan gave the highest fruit cluster 8, 7 and 7 per plant, respectively. Similarly, variety ARP tomato D2 showed superior in the rest parameters and scored greater marketable yield 22.18 ton ha^{-1}, followed by Cochiro which scored highest marketable fruit yield (JARC, 2014/15). Therefore, these results indicate that tomato varieties vary from each other in their yield performance even under the same growing location and condition.

Shushay Chernet and Haile Zibelo (2014) reported that nine nationally released tomato varieties were evaluated at Humera agricultural research center (HARC) and showed highly significant difference for most of the characters. The highest marketable yield was obtained by Melkasalsa (56.07 ton ha^{-1}) and the least yield was recorded by Bishola (17.89 ton ha^{-1}). Among the variety studied, Miya and Marglobe took the shortest period (96 days) to mature while Bishola was the late (120 days) maturing among the varieties. Jiregna Dufera (2013) also reported wide range of difference in maturity for 21 tomato genotypes studied in MizanTepi (Shushay Chernet and Haile Zibelo, 2014). Results from trials conducted on adaptability and yield performance of seven newly and five previously introduced hybrid tomato varieties on four locations of major tomato growing areas of Central rift valley of Ethiopia on farmers and researcher fields (Tesfa Binalfew *et al*., 2016) showed significant variation in their overall performance. The results also indicated that Venus was the highest yielding with preferable quality of tomato in Ethiopia.

Regarding tomato quality, Dar *et al.* (2012) reported that a total soluble solid (TSS) is very important quality character to determine the degree of sweetness. Total soluble solids varied among varieties grown in greenhouse. The value of total soluble solids content varied from 4.79% to 6.02% in different variety (Hossain *et al.,* 2010). In line with this report, Dar *et al.* (2012); and Gupta *et al.* (2011) reported that total soluble solids of fruit ranged from 3.67 to 6.0 ^{o}Brix in different tomato varieties. Titratable acidity and pH are the most commonly used acidity indicators of tomato and influenced by both growing conditions and tomato varieties. The highest TA and pH were observed in greenhouse than in open field condition. Among the varieties, Marglobe had the highest value for both variables (Yebirzaf Yeshiwas *et al*., 2016).

2.7. Genetic Variability, Heritability and Genetic Advance of Tomato Traits

2.7.1. Genetic variability

Genetic variation is the occurrence of differences among the individuals due to the differences in their genetic composition and the environment in which they are grown (Falconer and Mackay, 1996). Therefore, it becomes necessary to partition the observed phenotypic variability into its heritable and non-heritable components with suitable

parameters such as phenotypic and genotypic coefficient of variation, heritability and genetic advance (Mohammad Ahmed *et al*., 2012). The amount of variability that exists in the germplasm collections of any crop is of the utmost importance towards breeding for better varieties. Particularly, genetic variability for a given character is a basic prerequisite for its improvement by systematic breeding (Engida Tsegay *et al*., 2007).

Phenotypic variability is the observable variation present in a character in a population; it includes both genotypic and environmental variation and, as a result, its magnitudes differ under different environmental condition. Genotypic variability, on the other hand is the component of variation which is due to the genotypic difference among individuals within a population, and is the main concern of plant breeders (Singh, 2011). The study of phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) is not only useful for comparing the relative amount of phenotypic and genotypic variations among different traits but also very useful to estimate the scope for improvement by selection, because most of the economic traits are complex in inheritance and are greatly influenced by several genes interacting with various environmental conditions (Bello *et al*., 2012).

High PCV indicates the existence of a greater scope of selection for the trait being considered, which depends on the amount of variability present (Khan *et al*., 2009). High GCV indicates the presence of exploitable genetic variability for the traits, which can facilitate selection (Yadav *et al*., 2009). The differences between genotypic and phenotypic coefficient of variability indicate the environmental influence. The lower value of PCV generally depicts low variability among the tested sample; while a high proportion GCV to the PCV is desirable in breeding works. Therefore, the high values of GCV and PCV suggested that there is a possibility of improvement through direct selection for the traits (Hepziba *et al*., 2013).

So far a number of studies have been made on genetic variability of tomato. Mohanty (2003) reported high PCV and GCV for average fruit weight, number of branches and number of fruits per plant. Golani *et al.* (2007) also reported high PCV and GCV for number of locules per fruit, ten fruit weight, fruit yield and plant height while the same was medium for number of branches per plant, fruit length and fruit diameter and it was low for total soluble solids (TSS). Similarly, Pradeepkumar *et al*. (2001) obtained high

GCV and PCV for plant height, number of fruits per plant, pericarp thickness, locule number, total soluble solids (TSS), single fruit weight, yield per plant and number of harvest. Moreover, Shashikanth *et al*. (2010) reported high GCV and PCV for number of fruits per plant, average fruit weight per plant and fruit yield per plot while low GCV and PCV for days to first and 50 % flowering and days to first fruit set.

2.7.2. Heritability and genetic advance of traits

The concept of heritability which specifies the proportion of the total variation among a variety due to genetic components combined with genetic advance. These are good parameters for determining gene action involved in the inheritance of any trait and by extension help in deciding the best breeding method to apply for improving such trait. High heritability indicates less environmental influence in the observed variation (Songsri *et al*., 2008; Eid, 2009), while high heritability accompanied by high genetic advance is an indication of additive gene action for such trait, making it most amenable to selection (Tazeen *et al*., 2009).

Broad-sense heritability (H^2b) only indicates whether or not there is sufficient genetic variation in a population, which implies whether or not a population will respond to selection pressure (Gatti *et al*., 2005; Milatovic *et al*., 2010; Ullah *et al*., 2012). High heritability may not be always associated with large genetic advance. Since high heritability does not always indicate a high genetic gain, heritability is recommended to be considered in association with genetic advance to predict the effect of selecting superior crops varieties. To access a more effective trait selection, heritability accompanied by genetic advance is more useful than heritability alone (Ullah *et al*., 2012). Genetic advance denotes the improvement in the mean genotypic values of selected families over base population and thus helps the breeder to select the progenies in the earlier generation itself (Johanson *et al*., 1955).

Ghosh *et al*. (2010), reported high heritability (>60 %) in tomato genotypes for days to first flowering, plant height, number of branches per plant, flowers per plant, fruits per cluster, fruit clusters per plant, fruits per plant, fruit length, fruit diameter, individual fruit weight and fruit yield per plant. While it was medium for number of flowers per cluster (47.83%). Similarly, Hidayat ullah *et al.* (2008) obtained high heritability for days to first

harvest, number of fruits per plant, single fruit weight and number of locules indicated less influence of environments within specific year that could be exploited through simple selection from this material to improve yield. Pradeepkumar *et al.* (2001) also reported higher heritability (>80%) for plant height, days to maturity, number of fruits per plant, pericarp thickness, locule number, total soluble solids (TSS), average fruit weight and fruit yield per plant.

2.8. Correlation Coefficients

The degree of a linear association between two characters is measured by the correlation coefficient. Correlation, therefore, is helpful in determining the component characters of a complex trait, like yield. Such studies are useful in disclosing the magnitude and direction of these relationships between the different characters and yield as well as among the characters themselves (Falconer, 1996). Characters of crop plants are generally correlated. There are three types of correlations; phenotypic, genotypic and environmental correlations. The association between two characters that can be directly observed is the correlation of phenotypic values or phenotypic correlation. The phenotypic correlation measures the extent to which the two observed characters are linearly related. Genetic correlation is the association of breeding values (additive genetic variance) of the two characters. The genetic causes of correlation are mainly pleiotropic effects of genes affecting different characters. Pleiotropic is the property of a gene whereby it affects two or more characters, so that if the gene is segregating it causes simultaneous variation in the two characters it affects (Falconer, 1996). In early segregating generations, genetic correlation determines the degree of association between characters and how they may enhance selection. Depending on the sign, genetic correlations between two characters can either facilitate or impede selection progress. High values of genetic correlations may indicate considerable genetic association between the characters tested.

Ghosh *et al.* (2010) reported significant positive genetic and phenotypic correlation in tomato for number of fruits per plant and fruit yield per plant, fruit length and individual fruit weight, fruit diameter and individual fruit weight, number of flowers per plant and number of fruits per plant, flowers per plant and fruit yield per plant. On the contrary he obtained significant negative correlation for number of flowers per cluster and fruit

diameter, flowers per cluster and individual fruit weight and flowers per plant with individual fruit weight. Agong (2001) obtained negative genotypic and phenotypic association for fresh fruit weight and total soluble solids, single fruit weight and number of fruits per plant and number of fruits per plant and fruit width. He also reported positive association of fresh fruit weight with fruit width, fresh fruit weight and equatorial length.

According to Haydar *et al*. (2007) fruit weight per plant had significant correlation with number of flowers and number of fruits in three clusters/plant in tomato. Similarly, Hidayatullah *et al*. (2008) indicated number of pickings had positive correlation with fruit weight per plant and 1000 seed weight and number of fruits per plant had positive association with fruit weight per plant and seeds per fruit at both genotypic and phenotypic level in tomato.

2.9. Participatory Evaluation of Varieties

Participatory variety selection addresses problems of farmers that were not touched by the formal breeding system; for instance, evaluation of released and pre released varieties that enhance varietal diversity in farm cropping system (Sangay and Mahesh, 2010). Likewise, Thapa *et al*. (2009) and Tiwari *et al*. (2009) illustrated participatory variety selection as a desirable method to resolve problems in introduction and adoption of released varieties, in evaluation and selection for preferences of farmers for their target environments. Farmers' assessment of the performance of trial technology is crucial and the most important part of technology evaluation. Farmers are rational in their decision-making. Farmers will only decide to adopt technology if they are convinced of its benefits and if technology does not require unacceptable efforts on their part Therefore, involving farmers as active participants in the evaluation of recommended technological innovations can have several benefits for technology generation by agricultural research stations. This helps in getting a full understanding of the criteria farmers use to decide whether to adopt or reject recommendations (Bunders *et al.*, 1996).

Any technology or practice used by farmers represents a particular way to solve one or several problems. Each technology or practice responds to farmers' concerns in specific ways, which may be regarded as the traits or characteristics that define the technology or practice. Farmers can view some characteristics as positive or advantageous and others as

negative or disadvantageous. Any practice or technology entails trade-offs between its positive and negative traits. The choice of one technology/practice over others is greatly influenced by the balance between its positive and negative characteristics. Depending on the preferences, resources, and constraints that individual farmers face, a beneficial characteristic for one farmer may be a negative one for another, or the balance between positive and negative traits may be acceptable for one farmer but not for another.

Any new technology presented to farmers will either improve or substitute for the technological options they currently have. It is fundamental to identify these options and understand perceptions about the advantages and disadvantages of each one. Only then will researchers be able to assess the appropriateness of potential new technologies or practices, evaluate the likelihood that they will be adopted, and if necessary modify them to suit farmers' needs better. Farmers identify and select the type of crops most likely to do well in their areas. Selection is normally preceded by extensive discussions both within the farm family and with neighbors'. Any family member may make observations of crop performance, looking at the crop during weeding or other activities and noting any interesting variations. A good crop stand is often noticed by neighbors and becomes a subject of conversation within the community (Bunders *et al*., 1996).

Other authors also mentioned farmers' technology evaluation criteria such as growth habit, yield, colour of grain, main uses in the diet, processing and storage qualities, marketability, cost, ease of sale, desirability for home consumption, compatibility with existing practices taste, nutritional value, cooking quality and resistance to pests (Bunders *et al*., 1996).

Farmers' criteria will vary greatly between households, depending on the productive resources controlled by the household. However, the criteria also vary within a household. The division of responsibilities and tasks is socially defined according to gender and age. This means that different household members will evaluate a technology according to different criteria, which are related to their role and functions in the household (Bunders *et al*., 1996).

Chapter 3: MATERIALS AND METHODS

3.1. Description of the Study Area

A field experiment was conducted in Kobo district at Kobo Sub Centre of Sirinka Agricultural Research Center (SARC) during the 2021 offseason under irrigation. The SARC Kobo Sub Center is located in Amhara Region at 12° 08’ 21"N latitude and 39°38’ 21" E longitudes, with an altitude of 1450 meters above sea level and 571 km Northeast of Addis Ababa. The land escape is moderately gentle slope 8% and the soil texture of the experimental area is clay loam with a pH value of 7.2. The mean annual rainfall is 668 mm with maximum and minimum temperatures of 31℃ and 15 ℃, respectively (SARC, 2008). Most of the agricultural land of the district is allocated for annual crop production; where *teff*, sorghum, maize, check pea, tomato, onion and cabbage are the major crops produced. About 10342 ha of land in the district are irrigable (KWAPO, 2016).

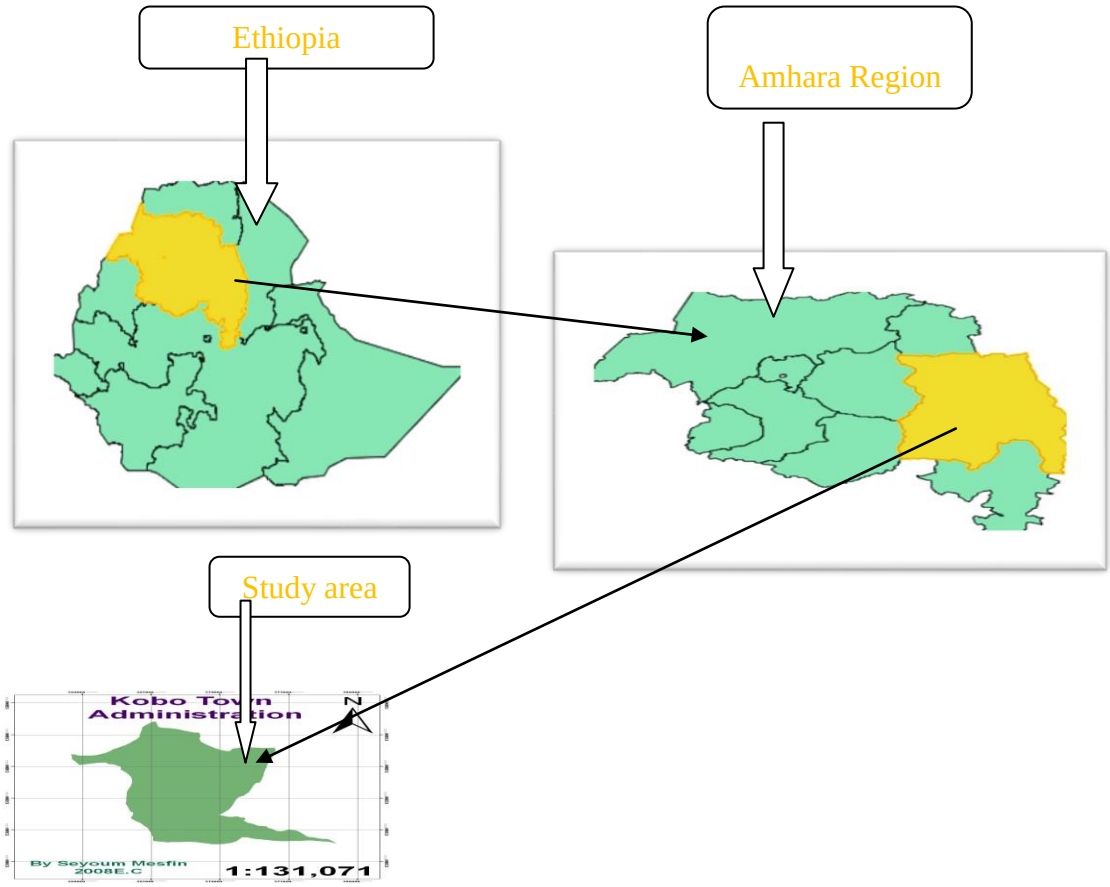

Figure3.1 Map locating the study area,* Source*: Ethio GIS shape file

3.2. Experimental Treatments, Design and Procedure

Sixteen tomato varieties obtained from Melkasa and Sirinka Agricultural Research Centers and one local variety from the farmers was evaluated for their variability and performance in the study area (Table 3.1). The treatments were laid out in Randomized Complete Block Design (RCBD) with three replications. The gross area of the experimental unit was 852 m^2 (56.8 m x 15 m). The size of experimental plots was 4 m x 2.4 m (9.6 m^2) with the net plot area of 2 m x 1.8 m (3.6 m^2). Seedlings was planted at the spacing 30 x 100 cm between plants in the row and between rows, respectively, as indicated by Naika (2005). A free space of 1 meter and 1.5 m between plots with in block and between blocks was kept for cultural practices.

Table 3.1 Tomato varieties used for study and some of their descriptions

Genotypes	Growth habit	Maturity days	Av. fruit weight (g)	Av. yield t/ha	Breeder/ maintainer	Year of release
Melka Salsa	Determinate	100-110	40-50	45.0	Melkasa	1998
Melka Shola	Semi-determinate	100-120	60-70	43.0	Melkasa	1998
Bishola	Determinate	85-90	140-150	34.0	Melkasa	2005
Eshete	Indeterminate	75-80	130-140	39.4	Melkasa	2005
Fetan	Determinate	75-80	110-120	45.4	Melkasa	2005
Metadel	Semi-determinate	75-90	90-140	34.5	Melkasa	2005
Mersa	Indeterminate	100-120	42	27.6	Sirinka	2006
Sirinka-1	Indeterminate	60-70	95-100	38.2	Sirinka	2006
Woyno	Determinate	85-90	40	24.9	Sirinka	2006
Chali	Determinate	86	85-90	43.0	Melkasa	2007
Cochiro	Determinate	85-90	70-80	46.3	Melkasa	2007
Miya	Semi-determinate	90-100	75-80	47.1	Melkasa	2007
ARP tomato D2	Semi-determinate	80-90	90-100	43.5	Melkasa	2012
Gelilema	Determinate	88	90	50.0	Melkasa	2015
Roma VF	Determinate	95-100	-	40.0	-	-
Gelila hybrid	Indeterminate	-	Up to 135	-	-	-
Sembersa local	-	-	-	-	-	-

Source: MoA (2016)

Seeds were sown in rows of 15 cm spacing on well prepared raised ground nursery beds having the size of 2m x1m at SARC Kobo Sub Center nursery site. Sown seeds were covered lightly with fine soil and then with two-three cm thick grass mulch. Watering was done daily until germination and then with three days interval after germination. Transplanting of seedlings on experimental field was done after 40 days at 3-5 true leave stage when seedlings attained the height of about 15-25cm. The experimental field was well prepared ahead of seedling transplanting using tractor and human labor. On each experimental plot, 32 seedlings were planted at the spacing of 30 cm x100 cm between plants and between rows, respectively. The whole amount NPS (242kg/ha) recommended to the area was applied during transplanting while the recommended rate of urea (79kg/ha) was applied in to two equal splits. The first half of urea was applied at two weeks after transplanting while the remaining half was applied starting flowers or one and half months after transplanting (Sirinka Agricultural Research Center, 2003).

Experimental plots were irrigated using furrow irrigation every 3day for the first two weeks to secure uniform establishment and then at weekly interval. The other standard field management practices such as weeding (three times); stalking /wood/ (Prior to flower initiation stage), diseases and insect-pests management was performed uniformly during the growing seasons. Some diseases and insect pests were observed during this experiment. Insect-pests such as trips, aphids and white fly and diseases like powdery mildew were a problem. Hunter 40 EC insecticide was alternatively sprayed. Spraying was done after thoroughly mixing insecticides in 500 ml water per hectare. Disease was managed by application of recommended fungicides Mancozeb750 DF at a rate of 2.5 kg ha $^{-1}$ (185kg/100L) in seven days intervals at seedling to transplanting date and 15 days interval at vegetative to pre-flowering stage.

3.3. Data Collection

3.3.1. Phenological and growth parameters

Days to 50% flowering: The number of days elapsed from date of transplanting up to the date when 50% of the plants in plot flowered was recorded and used for analysis.

Days to first harvest: The number of days elapsed from date of transplanting up to the date when 50% of the plants in plot contained at least one fruit red stage (over 90% red) as indicated by Rai and Yadav (2005).

Plant height (cm): Heights of five randomly taken plants from the ground level to the apex were measured using meter tape at the first harvest and the mean values were used for further analysis.

Number of primary branches per plant: The primary branches of five randomly taken plants in net plot area were counted at the first harvest and mean values were used for statistical analysis.

Number of secondary branches per plant: The secondary branches of five randomly taken plants in the net plot area were counted at the final harvest and the mean values were used for analysis.

3.3.2. Fruit yield and yield related traits

Number of flowers per cluster: Number of flowers in the tagged lower, middle and upper clusters of five randomly taken tomato plants was counted at 100% flowering stage and the mean values were computed and used for further analysis.

Number of clusters per plant: The number of clusters in five randomly taken plants in the plot was counted at first harvest and the mean values were used for further analysis.

Number of fruits per cluster: The number of fruits in lower, middle and upper clusters of pre- tagged five randomly taken tomato plants was counted at the first harvest and the mean values were computed and used for further analysis.

Fruit set percentage (%): It was calculated as the proportion of the number of fruits to the number of flowers per cluster expressed in percentage. following formula.

Fruit set (%) = NFrPC/ NFlPC x100 Where;

NFrPC = Number of fruits per cluster; and

NFlPC = Number of flowers per cluster.

Marketable fruit yield (tha^{-1}): fruits free from mechanical damages, insect pest and disease attacks and greater than 25 mm fruit diameter were considered as marketable (Lemma Dessalegn *et al.* 2002). The weight of such fruits harvested from each net plot area was weighed using scale balance and expressed as ton per hectare.

Unmarketable fruit yield (%)*:* Diseased and insect pest, mechanically damaged fruits and sun- burn, or under sized (<25 mm) fruit diameter etc. were considered as

unmarketable (Lemma Dessalegn *et al.,* 2002). The weight of such fruits harvested from each net plot area was taken and expressed as in percentage.

Total fruit yield (t/ha): It was obtained by adding marketable and unmarketable fruit yields

3.3.3. Fruit physical and chemical quality parameters

Fruit weight *(g)*: The weight of five randomly taken fruits at each harvest was weighed with sensitive balance and average values were taken for further analysis.

Fruit length (mm): The fruit length of five randomly taken fruits at each harvest was measured using caliper meter and the mean values were used for further analysis.

Fruit width (mm*)*: The diameter of five randomly taken fruits at each harvest was measured using caliper meter and the mean values were taken for analysis.

pH of tomato fruit juice: The juice of five randomly taken fruits from each replication was extracted using juice extractor. The aliquot of the juice was filtered with cheese cloth and the pH value of the juice was measured with a pH meter as indicated by **Acedo and Thah (2008).**

Fruit firmness (N): It was determined using a penetrometer (model: TMS-Pro, Food Technology Corporation, Sterling, VA, USA) by measuring the force required to make a predetermined piercing using a standard probe. Five randomly taken fruits from each replication were marked at two equal sides; then they were compressed by the probe to (10 mm) penetration depth using a conical plate at a speed of 10mm (Choi *et al*., 2018).

Total soluble solid (TSS) of fruit juice (Brix): An aliquot of juice was extracted from five randomly taken fruits harvested from each plot and 50 ml of the slurry was filtered using cheese cloth. The TSS was determined by hand refracto meter with a range of 0 to 32 °Brix and a resolution of 0.2 °Brix by placing 1 to 2 drops of clear juice on the prism.

Titratable acidity of fruit juice (%): Aliquot of juice was prepared according to the methods suggested by Acedo and Thanh (2008). The descant clear juice was used for the analysis. Titratable acidity was then determined by titrating 10 ml of tomato juice with 0.01N NaOH and calculated with the following formula.

$$TA\ (\%) = \frac{\text{Titre} \times 0.1N\ NaOH \times 0.064 \times 100}{1000}$$

Where; TA%=Titratable acidity percentage; Titre is the volume of tomato juice; 0.1N is the amount of NaOH used to neutralize 0.64 g of citric acid; and 0.64 is the conversion factor.

Juice content (%): Five randomly taken fruits from each plot were crashed and their juice was extracted by juice extractor and sieved with three level sieves and the juice content was calculated as follow:

$$\text{Juice content} = \frac{\text{Total weight of juice-beaker weight x100}}{\text{Total weight of fruit}}$$

Physiological weight loss (%): The percent weight loss was calculated by taking five fruits from each replication and recording the initial weight and weight after storage (one week) by using electronic balance. The fruits were stored on the raised bed / made from very thin wood/ which is good for aeration. The percent weight loss was calculated as:

$$\text{Percentage physiological weight loss} = \frac{\text{Weight of fresh fruit – weight after storage}}{\text{Weight of fresh fruit}} \text{ x100}$$

3.4. Data Analysis

Data were subjected to analysis of variance using the general linear model (GLM) procedure of SAS 9.1.3 (SAS Institute, 2012). Whenever treatment difference was found to be significant difference among the treatment means was compared using the Least Significance Differences (LSD) at 5% and 1% level of Significance (difference) (Gomez and Gomez, 1984).

3.4.1. Estimation of variance components

The phenotypic and genotypic variability present in the genotypes were estimated using phenotypic and genotypic variance and coefficient of variation. The phenotypic and genotypic variances and coefficient of variations were estimated according to the methods suggested by Burton and Devane (1953) as follows:

Genotypic variance ($\boldsymbol{\sigma^2 g}$) $= \frac{\text{MSg}-\text{MSe}}{\text{r}}$;

Where; $\sigma^2 g$ = Genotypic variance;MSg = Genotypic mean square; MSe =Environmental variance (Error mean square); and r = number of replications.

Phenotypic variance ($\sigma^2 p$) $= \sigma^2 g + MSe$

Where; $\sigma^2 g$ = Genotypic variance;

Me = Error variance; and

$\sigma^2 p$ = Phenotypic variance.

Environmental variance ($\sigma^2 e$) = MSe

Where; MSe = Mean square of error

Genotypic coefficient of variation (GCV) = $\frac{\sqrt{\sigma^2 g}}{X} x\ 100$

Phenotypic coefficient of variation (PCV) = $\frac{\sqrt{\sigma^2 p}}{X} x\ 100$

Environmental coefficient of variation (ECV) = $\frac{\sqrt{\sigma^2 e}}{X} x\ 100$

Where; X = Grand mean.

3.4.2. Estimate of heritability in broad sense

Heritability (H^2) in broad sense for all characters was computed using the formula adopted from Allard (1960) as;

Heritability in broad sense ($H^2 b$) = $\frac{\sigma^2 g}{\sigma^2 p}$

Where; $\sigma^2 g$ = genotypic variance; $\sigma^2 p$ = phenotypic variance.

Heritability (%) = $\frac{\sigma^2 g}{\sigma^2 p}$x100

Heritability percentage was categorized as demonstrated by Robinson *et al*. (1949).

Low =0 – 30%;

Moderate =30 – 60%; and

High =60% and above.

3.4.3. Estimation of genetic advance

Genetic advance (GA) and genetic advance as percent of the mean (GA %) for each characters was computed using the formula adopted from Johnson *et al*. (1955) and Allard (1960).

Genetic advance (GA) = k* $\sigma p * H^2 b$

Genetic advance percent of mean (GAM) = $\left[\frac{GA}{X}\right]$x100

Where; k= 2.06 at 5% selection intensity for trait;

σp = phenotypic standard deviation;

H^2b= heritability (Broad sense); and X= Grand mean

Genetic advance as percent mean was categorized as low, moderate and high as given by Johnson *et al*. (1955).

Low= 0- 30%;

Moderate= 30- 60% and

High = 60% and above.

3.5. Correlation analysis

Phenotypic correlation (the observed correlation between two variables, which includes both genotypic and environmental components between two variables) and genotypic correlation was carried out by Using SAS Software can disc procedures.

3.6. Participatory Evaluation of the Varieties

Twenty tomato growers were selected from the study kebeles (kobo 01) with the help of development agents. Training was given to the farmers to create general awareness about the experiment. Group discussion and debates was made to seriously observe and clear contradictory ideas on issue like farmers' preferences, criteria for evaluation and characteristics of good tomato varieties. Evaluation criteria were set by farmers' prior to evaluation. Participatory evaluation of genotypes was done at first harvest because most of the tested genotypes were not previously grown by farmers. Thus, the criteria farmers used in identifying the suitable genotypes depend on the existing constraints and opportunities farmers faced in their vicinity. Accordingly, vegetative performance; fruit yield; fruit shape; fruit size; fruit color; disease resistance and market preference were identified as the most important farmer's selection criteria. All of them were tabulated in a matrix scoring table and each selection criterion was compared with another in a pair-wise manner to identify farmers most preferred genotypes. Scores were given to each genotype based on the selection criteria 1 to 5 (1 = very good, 2 = good, 3 = average, 4 = poor and 5 = very poor) (Tewodros Mulualem and Negasi Tekeste, 2014).

During direct matrix ranking, farmers have given rating of importance (a relative weight) of a selection criterion. The score of each genotype was multiplied by the relative weight

of a given character to get the final result and then added with the results of other characters to determine the total score of a given genotype. Selection criteria identified by farmers were ranked depending on the number of repetition of each selection criterion chosen by the farmers.

Chapter 4. RESULTS AND DISCUSSION

4.1. Analysis of Variance

The mean squares from analysis of variance (ANOVA) for traits of seventeen tomato genotypes revealed highly significant difference (P< 0.001) among the genotypes for plant height, number of primary branches, number of secondary branches, days to 50% flowering, days to first harvest, number of clusters per plant, number of flower per cluster, number of fruit per cluster, fruit set percentage, marketable yield, total fruit yield, fruit length fruit width, single fruit weight, physiological weight loss, fruit pH, TSS, titratable acidity, firmness and fruit juice content (Table 4.1). These results indicated the presence of adequate genetic variability among tomato genotypes and the possibility of improving these traits through strong selection.

In agreement with the present findings, Jiregna Dufera (2008) and Alimaz Nibret (2021) reported existence of considerable genetic variability among tomato genotypes. Jiregna Dufera (2008) revealed considerable genetic variability among 12 tomato genotypes for the traits of plant height, number of primary branch, number of secondary branch, days to 50% flowering, days to first harvest, number of cluster per plant, number of flower per cluster, number of fruit per cluster, fruit set percentage, marketable yield (ton/ha) and total fruit yield (ton/ha) at Bako condition. Similarly, Alimaz Nibret (2021) reported existence of adequate genetic variability among eighteen tomato genotypes for the traits plant height, number of primary branch, number of secondary branch, days to 50% flowering, days to first harvest, number of cluster per plant, number of flower per cluster, number of fruit per cluster, fruit set percentage and marketable yield (ton/ha) at Fogera condition. In addition, Shamil Alo *et al.* (2017) found considerable variability among ten tomato genotypes for ten characters under Teppi condition. Furthermore, Haydar *et al.* (2007), Shankar *et al.* (2013) and Singh *et al.* (2015) revealed highly significant differences among genotypes in different countries. However, on contrary to the present results, Desalegn Regassa *et al.* (2016) found non-significant variation for days to 50% flowering, days to maturity, fruit numbers per cluster, total yield, fruit length and single fruit weight among tomato genotypes at Yabello research site, in southern Ethiopia.

Table 4.1 Analysis of variance for the 21 Parameters of genotypes in Kobo district the 2021 irrigation season

Parameters	MS		F value		Pr > F		LS	
	Var	Rep	Var	Rep	Var	Rep	Var	Rep
PH	999.41	91.83	25.8	2.37	<0001	0.109	**	Ns
NPB	1.52	3.98	3.46	9.08	<0001	0.018	**	*
NSB	7.23	13.54	6.84	12.8	<0001	<0001	**	**
DF	33.87	12.37	5.85	2.14	<0001	0.1345	**	Ns
DFH	72.29	8.17	6.89	0.78	<0001	0.4671	**	Ns
NCPP	60.75	9.50	5.93	0.93	<0001	0.40	**	Ns
NFlPC	2.43	1.96	5.06	4.08	<0001	0.25	**	Ns
NFrPC	2.18	1.57	9.04	6.53	<0001	0.42	**	Ns
FS (%)	150.20	3.57	3.35	0.09	<0018	0.9175	**	Ns
FW(g)	2333.5	273.3	9.68	1.13	<0001	0.3346	**	Ns
FL	135.76	28.78	14.9	3.16	<0001	0.055	**	Ns
FW	187.2	25.72	13.4	1.85	<0001	0.1739	**	Ns
MY	241.83	219.6	3.71	3.37	<0001	0.46	**	Ns
UNMY	35.46	117.7	1.66	5.57	0.107	0.008	Ns	**
TY	348.52	305.2	3.97	3.47	<0001	0.043	**	*
JC(%)	132.61	23.95	9.93	1.79	<0001	0.1827	**	**
pH	0.169	0.175	7.08	0.74	<0001	0.4869	**	Ns
TSS	1.59	0.106	6.41	0.43	<0001	0.6554	**	Ns
TA	0.278	0.030	9.62	1.05	<0001	0.3626	**	Ns
Frm	4.76	10.23	2.25	4.48	<0.05	0.0146	*	*
PWL	74.01	54.05	6.99	5.49	<0001	0.0089	**	*

*Note: PH= plant height; NPB= Number of primary branches; NSB= Number of secondary branches; DF= days to 50% flowering; DFH=days to first harvest; NCPP= number of clusters per plant; NFlPC= number of flowers per cluster; NFrPC= number of fruits per cluster; FS= fruit set percentage; FW= fruit weight; FL= fruit length; FW= fruit width; MY= marketable yield; Un MY= unmarketable yield; TY= total yield; pH= power of hydrogen; TSS= Total soluble solid; TA= titratable acidity; PWL= physiological weight loss; JC%= fruit juice content; Frm=fruit firmness; DF= degree freedom; SS= sum square; MS= mean square; LS=level of significance; Rep= replication; Var= variety; **highly significant; *significant and ns=not significant*

4.2. Mean Performances of Tomato Genotypes

4.2.1. Phenological and growth Parameters

Days to 50% flowering

Days to 50% flowering ($P < 0.0001$) showed very highly significant variation among tomato genotypes. Tomato genotypes Miya (37.00), Metadel (37.33), ARP D2 (38.00), Fetan (38.33) and Chali (40.33) were relatively earlier than the rest genotypes (Table 4.2). Early flowering varieties may mature early and require less time and labor expense that makes them appropriate for commercial cultivation in tropical conditions. Moreover, early flowering tomato varieties are expected be suitable to produce two crops per season. On the other hand, Sembersa (local) took 49.33 days, the longest time for flowering, but not statistically different from Mersa (47.33 days) and Roma VF (45.67 days) genotypes. All the tested genotypes took relatively shorter time to attain 50% flowering that might be due to relatively high temperature conditions of the study site in the growing season. In the present study, days to 50% flowering ranged from 37 to 49.33 days. In agreement with the present findings, Aleminew Tagele and Tibebu Tesfay (2017) found that days to 50% flowering ranged from 34 to 48 days among the five tomato genotypes evaluated at Sekota, northeastern Ethiopia. Meseret Degefa *et al*., (2012) also reported that days to flowering ranged from 38 to 49 days. However, these authors reported differently that 'Miya' and 'Fetan' were earliest to flower whereas 'Bishola' and 'Jimma local' showed statistically late flowering among the different varieties studied.

On the contrary to the present results, Dessalegn Regassa *et al*. (2016) reported that days to 50% flowering ranged from 71 to 74 days for four improved tomato varieties evaluated at Yabello Pastoral and Dry-land Agriculture Research Center, Ethiopia; this might be due to lower temperature (19 °C to 24 °C) of the experimental area. The difference in 50% flowering days can also be attributed to the genetic makeup of genotypes and environmental factors as observed by Abdelmageed and Gruda (2009).

Days to first harvest

Days to first harvest were highly significantly different ($P < 0.001$) among tested tomato genotypes. The mean value for days to 50% maturity varied from 71.33 to 86.667 days to produce horticultural matured fruit in the first harvest. Metadel (71.33), Woyno (74.67), Fetan (74.67), and Miya (75.00) tomato genotypes were relatively earlier than the rest of the tested genotypes but they were not statistically different. In the present study, genotypes like Miya, Metadel and Fetan relatively early matured which is probably due to those genotypes having early flowering days. On the other hand, maximum days required to attaining 50% maturity was recorded from Sembersa (88.67days), Mersa (86.67), RomaVF (86.33days), Gelilema (84.33), Gelila (83.67) and Sirinka (83.67) genotypes which were statistically similar (Table 4.2). These variations in days to fruit maturity could be due to the differences in the growing environment, climatic conditions and or due to the genetic make-up of the genotypes as stated by Fayaz *et al*. (2007). Early matured varieties are important for early marketing in the season which mostly fetch good price. Early maturing varieties may require less time and labor expense and are appropriate to produce two crops per season. On the other hand, late maturing tomato varieties need extra management and their production is mostly labor intensive.

In agreement with the preset findings, Meseret Degefa *et al.* (2012) reported that days to 50% maturity of tomato varieties varied from 83 to 99 days to produce horticultural matured fruits among the nine tomato genotypes evaluated in Jimma. Similarly, Shushay Chernet., Derbew Belew and Fetien Abay (2013) reported that maturity ranged from 73 to 93 days for 21 tomato genotypes evaluated in Mizan Tepi, Ethiopia. Jeriga Dufera, (2013) also reported a wider range of maturity (69-156 days) for 36 tomato genotypes evaluated in Humera, Ethiopia. Furthermore, various researchers reported that the first harvest of tomato varieties could vary from 70 to 120 days because of genetic and environmental factors (Moraru *et al.*, 2004; Fayaz *et al.*, 2007).

Plant height of tomato genotypes

Analysis of variance revealed that plant height showed highly significant ($P<0.0001$) difference among the tomato genotypes (Table 4.1). The tallest plant height was recorded

from Eshet genotype (106.733cm), which was not statistically different from Mersa (104.60 cm), Sirinka (101.26 cm) and Woyno (96.4 cm) genotypes. This result might be related to the fact that 'Eshet' is inherently an indeterminate type of tomato variety. According to Valdés-Gómez *et al, (*.2014), indeterminate type of tomato varieties can be harvested five times per cropping season. Indeterminate tomato varieties might require long growth period and special management practices such as stalking and may also face the incidence of diseases and insect pests in tropical climate. On the other hand, the shortest plant height was recorded from Cochiro (53.467cm), but not significantly different from Fetan (54.80cm), ARP D2 (58.13cm), Melkasalsa (58.53cm), Chali (59.26cm), Sembersa (59.33cm), Metadel (61.53cm) and Melka shola (62.66cm) genotypes (Tables 4.2). Such short varieties may not need stalking and their production may require less labor expense that makes them highly popular for commercial cultivation in tropical conditions (Naika, 2005). According to Valdés-Gómez *et al, (*.2014), short tomato varieties are most suitable to produce two crops per season. Overall, the mean plant height of the tested tomato genotypes ranged from 53.467cm to 106.733 cm. The tallness, shortness and other morphological variations are varietal characteristics, which are controlled by certain genes (Gebisa Benti *et al*., 2017).

The present results were in agreement with the findings of Gebisa Benti *et al*. (2017) who reported the highest plant height recorded from Eshet variety (122.01 cm) and the shortest plant height recorded from Chali variety (63.18cm) from combined analysis made over locations at Erer Valley Babile district Ethiopia. Similarly, Meseret *et al.* (2012) reported that plant height of tomato varieties ranged between 40.20 cm and 107.00 cm. Shushay Chernet and Haile Zibelo (2014) reported wide ranges in plant height (59 to 129 cm) among the thirty-six tomato genotypes evaluated in Humera areas. Furthermore, Hussain *et al.* (2001) reported wide range of differences (61.6- 126.5cm) in plant height among the ten tomato genotypes evaluated in Pakistan.

Number of primary and secondary branches per plant

The tested genotypes were highly significantly different ($P<0.001$) in number of primary branches per plant (Table 4.1) The highest number of primary branches was recorded from Eshet genotype (6.866), but it was not statistically different from Mersa (6.333), Woyno(6.06), Miya (5.30), and Sirinka (5.87) genotypes. The differences observed in

number of primary branches per plant might be due to genetic variations existed among varieties in response to the specific location. The number of branches per plant is mostly related to the yielding capacity of tomato variety (Shushay Chernet *et al*., 2013). On the other hand, Sembersa genotype produced the least number of primary branches (3.90), however, it was not statistically different from Cochiro (4.70), Bishola (4.80), Gelilema (4.86), ARP D2 tomato (4.933), Gelila (4.933) and Melka Salsa (5.00) genotypes (Table 4.2). Similarly, Sharma and Rastogi (1993) reported significant variation in number of branches among cultivars of tomato and increasing tendency in the number of branches with an increase in plant height. Overall, the mean number of primary branches among tested tomato varieties ranged from 3.90 to 6.86. Fayaz *et al.* (2007) also reported that primary branches of tomato ranges from 3.1 to 12.6 per plant at Bako research site. In addition, Tigist Minyamer *et al*., (2011) reported variable number of branches per plant for different cultivars.

In the present results, highly significant variation ($P<0.0001$) was observed in number of secondary branches per pant. The highest number of secondary branches was recorded from Chali (13.37), followed by Eshet (12.27) and Metadel (11.67) genotypes. Secondary branches per plant are related to the yielding capacity of tomato genotypes. Sembersa genotype produced the least number of secondary branches (7.50), which was not statistically different from ARP D2 (8.07), Bishola (8.93), Sirinka (8.93) and Cochiro (9.033) genotypes. The mean secondary branches of the tested tomato genotypes ranged from 7.50 to 13.37 (Table 4.2). Similar results were reported by Shushay Chernet *et al.* (2013) that significant variation was observed among tomato varieties for the number of secondary branches.

Table 4.2 Mean values of Phenological and growth parameters of 17 tomato genotypes tasted in Kobo district during 2021 irrigation season

Genotypes	Phenological Parameters			Growth Parameters	
	DF	DFH	PH	NPB	NSB
ARP D2	38.00f	77.67ef	58.13ef	4.93defg	8.07gh
Bishola	42.00cde	83.00bcde	69.80cd	4.80efg	8.93fgh
Chali	40.33def	78.00ef	59.27def	5.26bcdef	13.37a
Cochiro	42.00cde	78.67def	53.47f	4.7gf	9.03fgh
Eshet	44.00bcd	79.00cdef	106.73a	6.86a	12.27ab
Fetan	38.33ef	74.67fg	54.80f	5.30bcdef	9.47defg
Gelila	43.33cd	83.67abcd	72.40c	4.93defg	9.27efg
Gelilema	42.00cde	84.33abc	68.73cde	4.8efg	9.40efg
Melka salsa	43.33cd	81.67bcde	58.53def	5.00cdefg	9.87cdef
Melka shola	40.67def	82.00bcde	62.67bcdef	5.26bcdef	11.13bcd
Mersa	47.33ab	86.67ab	104.60a	6.33ab	10.80bcde
Metadel	37.33f	71.33g	61.53cdef	5.63bcdef	11.67ab
Miya	37.00f	75.00fg	66.33bcde	5.3bcdef	9.67defg
Roma vf	45.67abc	86.33ab	66.53bcde	5.46bcdef	10.87bcde
Sembersa	49.33a	88.67a	59.33def	3.90g	7.50h
Sirinka	44.00bcd	83.67abcd	101.26a	5.86abcde	8.93fgh
Woyno	42.00cde	74.67fg	96.40a	6.06abc	1 1.53bc
G mean	42.16	80.53	71.51	5.35	10.10
$LSD_{0.05}$	3.92	5.39	10.93	1.04	1.78
Sig difference	**	**	***	*	**
CV(%)	5.59	4.02	9.19	11.68	10.62

Note: PH= plant height; NPB= number of primary branches per plant; NSB= number of secondary branches per plant; DF=days to flowering; DFH=days to first harvest; **=very highly significant; *= significant; CV= coefficient of variation and LSD= least significance difference at 5% prob. Means followed with the same letter(s) in the same column are not significantly different.

4.2.2 Yield and Yield Related Traits

Number of clusters per plant

Results from analysis of variance showed highly significant difference ($P < 0.0001$) among tested tomato genotypes for number of clusters per plant (Table 4.1). Among the tested tomato genotypes, Melka Salsa (28.11) produced the highest number of clusters, followed by Melka Shola (22.11), Roma VF (22.11) and Woyno (20.89) genotypes (Table 4.3). On the other hand, genotype Eshet (12.223) produced the least number of clusters per plant, but not significantly different from Bishola (12.667), Metadel (12.889), ARP D2 (12.93) and Gelila (13.557) genotypes. The observed difference in the production of clusters is probably due to the inherent potential of the genotypes which was also indicated by the research results of Mohanty *et al*. (2003). The production of clusters is one of the major criteria in selecting tomato genotypes and it determines the yielding potential of genotypes (Tadele Shiberu 2016).

The present results are in agreement with the findings of Milkinesh Tujuba and Negash Geleta (2020) who reported that number of fruit clusters per plant ranged from 10.42 to 31.53 for the twelve tomato genotypes evaluated at Guto Wayu and Bako, Tibe districts of western, Etiopia. Similarly, Shushay Chernet and Haile Zibelo (2014) also reported that number of fruit clusters per plant ranged from 9.6 to 27.4 for the nine tomato genotypes evaluated at Humera Agricultural Research Center, Ethiopia.

Number of flowers per cluster

The number of flowers produced per cluster was significantly different ($P < 0.05$) among the tested genotypes (Table 4.1). The highest number of flowers per cluster was produced by Mersa genotype (7.11), which was statistically similar with Melka Salsa (6.48) and Chali (6.21) genotypes; while, the least number of flowers per cluster was recorded by Sembersa genotype (3.66), which was not statically different from Gelila (4.22) and Fetan (4.33) genotypes (Table 4.3). In the present study, genotypes with high number of flowers per cluster like Chali, Eshet and Metadel relatively gave the highest yield which is probably due to higher number of fruits arising from higher number of flowers per cluster. An increased production of flowers on tomato plant has greater probability in fruit set

percentage that may lead to higher yield. In agreement with the present findings, Meseret Degefa *et al.* (2012) found 2.27 to 5.89 flowers per cluster among tomato varieties. Similarly, Shushay Chernet and Haile Zibelo (2014) reported that number of flowers per cluster ranged from 3.80 to 4.40 among nine tomato genotypes evaluated at Humera.

Number of fruits per cluster

The number of fruits per cluster were highly significantly ($P<0.05$) different among the genotypes (Table 4.1). The genotype Melka Salsa (5.73) produced the highest number of fruits per cluster, which was not statistically different from Mersa (5.40), Metadel (5.10) and Eshet (4.94) genotypes; this indicates that those genotypes had the highest number of flowers per cluster from other genotypes, suggesting that number of fruits is strongly influenced by the number of clusters and by the number of flowers per cluster. On the other hand, genotype Sembersa (2.41) produced the lowest fruit numbers per cluster which was statically similar with ARP D2 (2.91) genotypes; these genotypes had the least number of flowers per cluster. The mean number of fruit per cluster of the tested tomato genotypes was ranged from 2.41 to 5.72 fruits per cluster (Table 4.3).

These results were in harmony with the findings of Milkinesh Tujuba and Negash Geleta (2020) who reported that significance difference among tomato varieties for the number of fruit per cluster. The same authors also reported that the highest number of fruit per cluster was recorded from genotype Melka salsa evaluated at Wayu Tuka, and Bako Tibe districts of western, Etiopia. Similarly, Shamil Alo *et al.* (2017) reported that number of fruits per cluster ranged between 2.13 and 5.00 among ten tomato genotypes evaluated at Teppi, South Western part of Ethiopia. They reported that Melka Salsa (5.00) gave the highest fruit number per cluster. Meseret Degefa *et al.*, (2012) also reported that the number of flowers per cluster affects the number of fruits per clusters. It is one of the major criteria to select variety for its higher yielding potential. In general, the higher the number of fruits per cluster the more fruit yield is expected, although fruit size also determines the yield estimation (Tadele Shiberu. 2016).

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Fruit set percentage

The result of ANOVA showed that there was significant ($P \leq 0.05$) variation among the genotypes for Fruit set percentage. The genotype Melka salsa (88.41) produced the highest number of fruits set percentage, which was not statistically different from Miya (86.42), Metadel (85.10) and Fetan (84.23) genotypes. In this study, the genotypes that had the highest number of flowers per cluster had not the highest fruit set percentage, suggesting that those genotypes had high deflowering problems; might be due to their genetic makeup with environmental factors. Therefore, fruit set percent is one of the major important parameters in choosing tomato varieties for summer and rainy season production, thus it determines the resistance and/or tolerance of a variety to temperatures and other environmental conditions (Jones, 2008). Genotype ARP D2 (64.33) produced the lowest fruit set percentage which was statically similar with Sembersa (66.50) and Sirinka-1(68.80) genotypes. The mean number of fruit set percentage of the tested tomato genotypes was ranged from 64.33 to 88.41 % (Table 4.3). Similarly, Meseret Degefa *et al*. (2012) reported an average fruit set percentage of tomato flowers ranged between 60.67% and 73.33%.

In harmony with the findings, Singh *et al.* (2014) also reported that fruit set percentage ranged from 50.65 to 84.09% among fourteen tomato hybrid varieties. Additionally, Khah *et al*. (2006) indicated that the average fruit set percentage of tomato flowers ranged between 66.1% and 78.5%.

Fruit weight, length and width

The results from indicated that there was highly significant difference ($P < 0.0001$) for fruit weight among the tested tomato genotypes (Table 4.1). The genotype Eshet (125.58g) and Metadel genotypes recorded the highest fruit weight. The lowest fruit weight was scored from Melka salsa (40.65g) genotype, which was statistically similar with Roma VF (43.49), Mersa (47.87), Sirinka (49.48) and Sembersa (54.34). This difference in fruit weight of tomato genotypes might be due to inherent difference in cultivars or growing environments. Overall, the mean fruit weight of the tested tomato genotypes was ranged from 40.65g to 125.58g (Table 4.3). The present result is in line with the fruit size standards reported by Lemma Desalegn (2002) that the average weight of tomato fruits ranged from 20-to180 g. Therefore, the present result showed considerable variation in fruit size among genotypes and suggesting that fruit weight is one of most important traits

can be considered in tomato selection for high fruit yield. It has been also reported that fruit weight is directly linked with yield (Jindal *et al.*, 2015).

In harmony with the present findings, Negash Geleta (2020) reported the highest fruit weight was recorded from Eshet genotype (125.54 g) and the lowest fruit weight was recorded from Miya genotype (46.33g). Similarly, Yebirzaf Yeshiwas *et al*. (2016) reported that the weight of fruit ranged from 99.23 to 133.24g among the four tomato genotypes evaluated in Jimma University, Ethiopia. Shumbulo Abrham *et al*. (2018) also reported that the weight of fruit ranged from 42.00 to 118.17g among the ten tomato genotypes evaluated in Wolaita, Southern Ethiopia. According to Yamaguchi (1997), tomato fruits are categorized into small, medium and large based on the fruit weights with the value of <50g, 70-110g, 110-170g and >180g, respectively. Medium and large fruit categories are preferred generally for fresh market.

Similar to fruit size, highly significant difference ($P < 0.0001$) was recorded in fruit length among the tested tomato genotypes (Table 4.1). The highest fruit length was recorded from Mersa genotype (70.8mm), followed by Gelila genotype (65.5mm); whereas, the lowest fruit length was recorded from Sirinka-1 genotype (45.9mm), which was statistically similar with Woyno (46.2mm), Miya (46.7mm) and Cochiro (50.8mm). The present findings are in agreement with finding of Hossain *et al*. (2010) that the average fruit length of tomatoes was ranging from 33.5 to 51.4 mm. This difference in fruit length of tomato genotypes might be due to inherent difference in cultivars. Therefore, the present result suggesting that fruit length is one of most important traits can be considered in tomato selection.

Furthermore, highly significant difference ($P < 0.0001$) was recorded for fruit width among the tested tomato genotypes (Table 4.1). The highest fruit width was observed in Eshet genotype (63.5mm) which was statistically similar with Bishola (60.6mm) and Metadel (58.6mm). This is attributed to the fact that 'Eshet' had large fruit size than the other genotypes. On the other hand, the lowest value of fruit width was recorded in Roma VF(38.0mm) which was statistically similar with Mersa (38.7), Melka Salsa (39.5mm) genotype (Table 4.3). In line with the present findings, Shushay Chernet and Haile Zibelo (2014) revealed the existence of variability in terms of fruit diameter among nine tomato varieties evaluated at Humera, Northern Ethiopia. They also reported that the highest fruit

width was recorded from Eshet genotype in their study. Depending on the type of genotypes, tomato fruit width ranges from 32 to 106.7mm (Kaushik *et al*., 2011; Rashidi and Gholami, 2011) which is in line with the findings of the present study. It has been indicated that the genetic makeup of the genotypes has great influence on size, length and width of tomato fruits (Atherton and Rudich, 1986).

Table 4.3. Mean values of yield related traits of 17 tomato genotypes in Kobo district during the 2021 irrigation season

Genotypes	NCPP	NFlPC	NFrPC	FS (%)	FW (g)	FL (mm)	FWd(mm)
ARP D2	12.93f	4.55efgh	2.91hg	64.33g	99.13bc	56.73def	56.93bc
Bishola	12.67f	4.55efgh	3.69defg	81.36abcd	104.81abc	51.47ghi	60.07ab
Chali	16.67cdef	6.216abc	4.48bcd	71.71defg	70.17defg	55.87defg	49.80def
Cochiro	13.60ef	5.14cdefg	4.09def	80.07abcd	83.71cde	50.80hij	50.40de
Eshet	12.22f	5.99abcd	4.94abc	82.67abcd	125.58a	52.27fgh	63.53a
Fetan	14.55def	4.33fgh	3.64efg	84.24abc	92.91bcd	54.27efgh	55.07bcd
Gelila	13.56ef	4.22gh	3.45fg	82.43abcd	110.83ab	65.53b	54.00bcd
Gelilema	19.00bcd	5.44bcdef	4.00def	73.62cdefg	81.43cdef	62.33bc	51.20cde
Melka salsa	28.11a	6.48ab	5.73a	88.41a	40.65h	59.40cd	39.47hi
Melka shola	22.11b	5.50bcde	4.43bcde	80.87abcd	57.16fgh	56.87def	43.73fghi
Mersa	15.41def	7.11a	5.40a	75.89bcdef	47.87gh	70.87a	38.73i
Metadel	12.89f	5.99abcd	5.1ab	85.10ab	117.31ab	53.33fgh	58.67ab
Miya	18.11bcde	4.89defg	4.22cdef	86.42ab	58.23efgh	46.73ij	46.73efg
Roma VF	21.11bc	5.05defg	3.86def	78.32abcde	43.49h	56.20defg	38.00i
Sembersa	19.11bcd	3.66h	2.41h	66.50gf	54.34gh	59.07cde	41.80hi
Sirinka	18.81bcd	5.46bcdef	3.77def	68.80efg	49.48gh	45.93j	44.07fghi
Woyno	20.89bc	5.83bcd	4.48bcd	77.19bcdef	57.23fgh	46.27j	45.27efgh
G mean	17.16	5.31	4.10	78.11	76.13	55.52	49.26
$LSD_{0.05}$	5.10	1.33	1.06	10.95	25.83	5.02	6.20
Sig difference	**	*	*	*	**	**	**
CV(%)	17.86	15.08	15.59	8.43	20.40	5.43	7.57

Note: *NCPP= number of clusters per plant; NFlPC= number of flowers per cluster; NFrPC= number of fruits per cluster; FS= fruit set percentage; FW= Fruit weight; FL= Fruit length; FWd= Fruit width; $LSD_{0.05}$= least significance difference at 5% prob;**highly significant; *significant and CV= coefficient of variation; and Means followed with the same letter(s) in the same column not significantly different.*

Marketable, unmarketable and total fruit yield

Analysis of variance for marketable fruit yield revealed a highly significant difference ($P < 0.001$) among the tested tomato genotypes (Table 4.1). The highest marketable fruit yield was recorded from genotype Chali (59.62 t/ha) followed by Eshet (51.95 t/ha), Metadel (51.12 t/ha), Melka salsa (47.43 t/ha) and ARP D2 (46.59 t/ha) which were statistically similar when compared each other. This highest marketable yield was due to the integration of highest number of fruit clusters per plant, number of flowers per cluster and number of fruits per cluster and fruit weight recorded on the above genotype. The genetic make-up of the variety also plays significant role on yield of these genotypes and also those genotypes were less affected by local tomato worms when it is compared with other genotypes planted at the study area. The lowest fruit yield was recorded from Mersa (24.72 t/ha), followed by Sembersa (24.93 t/ha), Sirinka (31.81) and Gelilema (38.01) which were statistically similar each other (Table 4.4). Tomato genotypes studied in these experiment were relatively good marketable yields compared to the findings of Meseret Degefa et al. (2012) who reported the marketable fruit yield ranging from 7.21-43.80 t ha-1 in their study; this might be due to the differences environmental factors (temperature, soil etc…) in study area and genotypes tested.

The present study are in agreement with the findings of Shushay Chernet and Haile Zibelo (2014) who reported that the marketable yield of ten tomato genotypes ranged from17.89 to 56.07 t/ha that evaluated at Humera, Northern Ethiopia. Seifudin Mehadi *et al*. (2016) also reported that the highest marketable yield was recorded by 'Chali' from ten tomato genotypes evaluated in the lowlands of Bale, South-Eastern Ethiopia. However, on the contrary to the present study, Shumbul Abrham *et al.* (2018) found that the highest marketable fruit yield (37.56 t/ha) was recorded by variety 'Melka shola' while the lowest (21.59t/ha) was recorded by 'Chali' among ten tomato genotypes evaluated at Abela site, Humbo Woreda in Wolaita Zone of Southern Ethiopia; this difference in marketable fruit yield might be due to high temperature (max. 32 ℃) of the study area. It has been reported that temperature higher than 29 ℃ causes restriction of pollen release and resulting in incomplete fertilization of ovules (Bok *et al.,* 2006).

Unmarketable fruit yield was not significantly different ($P > 0.05$) among the tested tomato genotypes (Table 4.1). The average unmarketable fruit yield was ranging from (4.65 t/ha; 8.78%) to (14.71t/ha; 24.62%) (Table 4.4). According to Lemma Dessalegn (2002), sun burnt, small sized cracked disease and insect pest damaged fruits are considered as unmarketable. In addition, this difference could be due to diseases and insect pests, the major constraints of tomato production in tropical country which result an increase in unmarketable yield.

Similar to marketable, highly significant ($P<0.001$) difference was observed in total fruit yield among the tested genotypes (Table 4.1). The highest was recorded from genotypes Chali (67.4t/ha), followed by Eshet (63.77t/ha), Metadel (62.23t/ha), Bishola (58.47 t/ha), ARP D2 (55.34 t/ha), Fetan (53.62 t/ha) Miya (53.50 t/ha), Melka shola (53.12 t/ha) and Melka salsa (52.08 t/ha) genotypes which were statistically similar each other. On the other hand, the lowest total yield was obtained from genotypes Sembersa (28.40 t/ha). The results are generally in agreement with Lemma Dessalegn (2002) and Meseret Degefa *et al*. (2012) who reported that total fruit yield of tomato ranging from 6.46-82.50 t/ ha in their studies. Similarly, in this study Firas *et al*. (2012) who reported that total fruit yield of tomato ranging from 25.9-52.90 t/ ha in their studies. The variation in total yield of tomato might be due the variation in the genetic makeup of different cultivars.

Table 4.4 Mean values of marketable, un-marketable and total Fruit yield of 17 tomato genotypes evaluated in Kobo district during the 2021 irrigation season

Genotypes	Marketable fruit yield (t/ha)	Unmarketable fruit yield (%)	Total fruit yield (t/ha)
ARP D2	46.59abc	16.41bc	55.34abc
Bishola	43.76bcd	24.62a	58.47abc
Chali	59.63a	11.46bc	67.44a
Cochiro	39.35bcd	18.45ab	48.68bcd
Eshet	51.96ab	18.48ab	63.77ab
Fetan	43.73bcd	18.22ab	53.62abc
Gelila	41.69bcd	15.06bc	49.07bcd
Gelilema	38.01cde	15.55bc	44.97cde
Melka salsa	47.433abc	8.78c	52.08abcd
Melka shola	44.98bcd	15.59bc	53.12abc
Mersa	24.73e	18.41ab	30.36ef
Metadel	51.12abc	17.56ab	62.20ab
Miya	44.25bcd	17.42	53.50abc
Roma VF	39.03bdc	14.50bc	45.29cde
Sembersa	24.93e	13.14bc	28.40f
Sirinka	31.81de	14.65bc	36.87def
Woyno	41.05bcd	14.89	48.63bcd
G mean	42.00	16.07	50.11
$LSD_{0.05}$	13.42	Ns	15.59
Sig difference	**	Ns	**
CV (%)	19.20	28.72	18.70

*Note: G-mean=grand mean, ns=not significant difference, **highly significant; *significant; CV=coefficient of variation; $LSD_{0.05}$= least significant difference at 0.05 prob.; and Means followed with the same letter(s) in the same column are not significantly different.*

4.2.3. Tomato Fruit Quality Parameters

Fruit juice content

Analysis of variance for fruit juice content revealed a highly significant difference ($P < 0.001$) among the tested tomato genotypes (Table 4.1). The fruits from Chali (93.3%) genotype had the highest juice content, followed by Eshet (92.47%), Gelila (91.26%), Metadel (90.23%), Bishola (89.26%), ARP D2 tomato (88.18%), and Fetan (87.66) genotypes which were statistically similar each other (Table 4.5). The lowest juice content was found in the fruits of Sembersa with the value of (70.27%), followed by and Mersa (75.00%), and Roma VF (75.91%) genotypes which were statistically similar each other. Juice content of tomato fruit is an important parameter for selection of variety as it determines its utilization. Based on the juice content of the fruits, the genotypes Chali, Eshet, Gelila and Metadel which have relatively high juice content, are suitable for agro-processing industry (Moreno *et al.,* 2009), while the genotype Sembersa, Roma VF, Mersa, Melkashola, and Melkasalsa have relatively low juice content are suitable for fresh market.

These results are in line with the findings of Miles *et al.* (2012) who reported that juice content of eight tomato genotypes ranged from 75.1% to 99.3%. According to the authors, tomato products such as tomato pastes and tomato juices have remarkably high concentration of minerals and vitamins such as vitamin C, vitamin E and pro-vitamin A. In addition, tomato juices also contain valuable phytochemicals or bioactive components such as lycopene and phenolic compounds and carotenoids (b-carotene). These nutritionally valuable compounds are however affected by the types of variety and the stages of maturity, and processing and storage conditions of tomatoes (Moreno *et al.,* 2009).

Fruit juice pH value

The analysis of variance showed that pH value of juices was significantly (*P<0.001*) different among 17 tested tomato genotypes. A juice made from Woyno had relatively acidic with the pH values of 4.24, followed by Gelila (4.33), Srinka-1 and ARP D2 (4.36), Melka shola (4.37), Metadel (4.37) and Miya (4.37) genotypes; this implies that those

genotypes had better quality than the other genotypes. Low pH values of tomato juice are associated with high fruit quality which is accounted to the flavor and sourness of the fruits. However, fruit juices of Sembersa (4.86), and Mersa (4.57) genotypes had relatively higher pH values. Increment in the pH value is associated with quality loss during fruit postharvest storage (Ram, 2005). Generally, this difference in fruit pH might be due to the genetic makeup of a variety that determines the pH of the fruits and thus the flavor and sourness of the fruits (Stevens *et al.,* 1977).

Total soluble solid (TSS) and Titratable acidity (TA)

In the present study, total soluble solid (TSS) showed highly significant differences ($P<0.001$) among tomato genotypes (Table 4.1). The highest TSS recorded from Mersa (4.6%), but not statistically different from Fetan (4.56%), ARP D2 (4.53%), Cochiro (4.47%), Bishola (4.3%) and Gelilema (4.00%) genotypes. This implies that these genotypes had high quality when they compared with other genotypes, due to having lower incidence of fungal infection. However, genotype Roma VF (2.8%), Melka salsa (3.3%), Metadel (3.66%) and Miya (3.66%) contained the lowest TSS. These results might indicate difference in genetic potential of tomato genotypes for total soluble solid accumulation. TSS of tomato fruit are influenced mostly by the genetic makeup of the variety, in addition to environmental influence (Milkinesh Tujuba and Negash Geleta, 2020). The TSS and TA contents of fruit is one of the major criteria in selecting of tomato variety for fresh market as it determines the sugar and acid content of a fruit that influences the overall flavor of the fruit (Stevens *et al*., 1977).

The present results are agreed with the findings of Amira *et al.* (2013) who reported that TSS of thirteen tomatoes genotypes ranged from 2.02 to 4.5%. Abdel-Sattar *et al.* (2021) also reported that TSS of five tomatoes genotypes ranged from 3.70 to 4.98%. The value of total soluble solids content varied from 4.79% to 6.02% in different varieties (Hossain *et al.,* 2010). In line with the present report, Dar *et al.* (2012); Gupta *et al.* (2011) reported that quality attributes like total soluble solids of the tomato fruit ranged from 3.67 to 6.0 ^{o}Brix in different tomato varieties.

However, on contrary to the present result, Singh *et al.* (2014) reported that TSS of fourteen tomato hybrid varieties ranged from 4.90 to 7.98%. These results are very high

when compared to present results; this might be due to growth condition (polyhouse), harvesting stages and the tested genotypes (hybrids). Furthermore, the total sugar content and acidity of cultivated tomato taste are considered to be one of the most important characteristics in its breeding for commercial and industrial utilization (Rodıca *et al*., 2008). High sugars are required for best flavor (Kader, 2008).

In the present study, titratable acidity showed highly significant differences (P<0.001) among tomato genotypes (Table 4.1). The highest value of TA was recorded from Chali (1.26%) genotype which was statistically similar with Gelila (1.07%) and Eshet (1.04%) genotypes. The lowest TA value was recorded from Sembersa genotypes (0.115%), but not statistically different from Mersa (0.116%) genotype. Genotypes with higher titratable acidity could have lower incidence of fungal infection and suitable for processing (Tigist Minyamer *et al*., 2011). Kader *et al*. (2008) also reported that high quality fruit should have TA and TSS greater than 0.32% and 3%, respectively. Decline in the acidity level associate with quality loss during fruit postharvest storage and together with soluble solids content, can influence consumer's acceptability. Quality attributes generally changes with time, as part of the normal metabolism of the product.

The present results are in agreement with the findings of Stevens and Rick (1986) that TA of tomato fruits varied from 0.40% to 0.91%. Abdel-Sattar *et al.* (2021) also reported that TA of five tomatoes genotypes ranged from 0.35 to 0.40%. In addition, Sinha, *et a*l,. (2020) found that TA of tomato fruits varied from 0.5% to 1.2%. Similar variation in titratable acidity was reported by Caliman *et al.* (2010). The reduction of titratable acidity with prolonged storage duration and with advancement of maturity stages as fruit ripens is due to the metabolic activities of living tissues that take place and further oxidation of organic acids to sugar (Genanew Tessema, 2013). Bhattarai and Gautam (2006) also stated that the fruit itself might utilize the acids so that the acid in the fruits storage periods decreases.

Fruit firmness

The highest value of firmness was recorded from Cochiro (7.26N) genotype, which was statistically similar with Fetan (7.25N), Gelila (7.23N), Woyno (6.95N), Miya (6.47N), ARP D2 Tomato (5.91N), Roma VF (5.56N), Gelilema (5.45N), Sembersa (5.43N), Eshet

(4.95N), and Sirinka-1(4.93N) genotypes. High quality fruits have a firm appearance, uniform and shiny color, without signs of injury, shriveling or decay (Moretti *et a*l, 2002). On the other hand, the lowest firmness value was recorded from Mersa (3.27N), but not statistically different from Bishola (3.74N), Melka Salsa (4.10N), Metadel (4.14N) and Chali (4.74N) genotypes. Bosland (1993) stated that genetic background, growing conditions and fruit constitution at the time of testing (degree of ripeness, size, post-harvest handling and internal temperature) affect fruit firmness. Lownds *et al*. (1993) also found a very pronounced decrease in fruit firmness to be associated with increase in weight loss during prolonged storage of tomato. Additionally, Maalekuu *et al.* (2004) showed strong correlations between weight (water) loss rates and both general fruits appearance and fruit firmness.

Physiological weight loss of fruits

Physiological weight loss of fruits showed highly significant difference ($p < 0.001$) among the tested genotypes (Table 4.1). The highest physiological weight loss was recorded from Miya (25.30%) genotypes followed by Woyno (24.40%) genotypes. These genotypes have lower firmness due to this the highest physiological weight loss was recorded. On the other hand, the lowest physiological weight loss was recorded from Eshet genotypes (10.36%), but not statistically different from Gelila (11.66 %) genotype (Table 4.5). These genotypes have the higher firmness.

The higher respiration rate resulted in higher transpiration of water from the fruit surface which led to increase in percentage of weight loss (Sabir *et al*., 2004). Weight (water) loss is the principal cause of fruit softening and shriveling. Respiration is a central process in living cells that mediates the release of energy through the breakdown of carbon compounds and this gives an indication of the overall metabolism of the plant part which utilizes the plant product as its substrate thereby leading to weight loss and shriveling. Therefore, Miya and Woyno genotypes had the highest respiration rate when they compared to the other genotypes and this may be due to variations in the genetic make- up of the individual genotypes in response to respiration rates which is an indication of weight loss, as indicated by Sabir *et al.*, (2004). The percentage of physiological weight loss increased progressively with increase in storage duration and with advancement of physiological maturity stages. Similar findings were also reported by Tolasa *et al*. (2021).

Table 4.5 Mean values of quality traits of 17 tomato genotypes evaluated in Kobo district during the 2021 irrigation season

Genotypes	JC%	pH	TSS (%)	TA (%)	PWL (%)	Frm(N)
ARP D2	88.18abcd	4.36cd	4.53a	0.87bcd	13.49efgh	5.91abcd
Bishola	89.26abcd	4.42bcd	4.30a	0.94bc	13.59efgh	3.74de
Chali	93.33a	4.46bc	4.16ab	1.26a	21.23abc	4.74bde
Cochiro	84.66cde	4.49bc	4.47a	0.75cd	16.02cdefg	7.26a
Eshet	92.47a	4.40bcd	4.06ab	1.04ab	10.36h	4.95abcde
Fetan	87.66abcd	4.38bcd	4.56a	0.74cd	15.19defgh	7.25a
Gelila	91.26ab	4.33cd	4.06ab	1.07ab	11.16gh	7.23a
Gelilema	85.37bcde	4.5bc	4.00a	0.59de	13.48efgh	5.45abcde
Melka salsa	80.42efg	4.35cd	3.30ab	0.84bcd	18.18bcdef	4.10cde
Melka shola	77.54fg	4.37bcd	3.76ab	0.82bcd	24.36a	5.32abcde
Mersa	75.00gh	4.57b	4.60a	0.12f	23.23ab	3.27e
Metadel	90.23abc	4.37bcd	3.66ab	0.86bcd	13.25fgh	4.14cde
Miya	81.44ef	4.37bcd	3.66ab	0.82bcd	25.30a	6.47abc
Roma VF	75.91fgh	4.43bcd	2.8b	0.61de	20.30abcd	5.56abcde
Sembersa	70.27h	4.86a	4.13ab	0.12f	18.81bcde	5.43abcde
Sirinka	85.14cde	4.36cd	3.90ab	0.44e	22.09ab	4.93abcde
Woyno	83.87de	4.24d	3.76ab	0.65de	24.40a	6.95ab
$LSD_{0.05}$	6.07	0.25	0.82	0.28	5.41	2.41
Sig difference	**	**	**	**	**	*
CV (%)	4.33	3.72	12.12	22.96	18.16	26.63

*Note: JC=Juice content, TSS= Total Soluble Solid; TA= Titratable Acidity; PWL= physiological weight loss; FM= fruit firmness; **highly significant; *significant; ns= not significant; CV= coefficient of variation; and $LSD_{0.5}$=least significant difference; and Means followed with the same letter(s) in the same column are not significant*.

4.3. Estimates of Genetic Parameters

4.3.1. Estimates of variance components

Estimates of phenotypic $\sigma^2 p$, genotypic variance, $\sigma^2 g$ and environmental variance $\sigma^2 e$ are presented in (Table 4.6.). The highest genotypic variance and phenotypic variance were 697.44 and 777.83, respectively for average single fruit weight; indicating the presence of high variation for this trait. The lowest, genotypic and phenotypic variances were 0.05 and 0.052, respectively for fruit juice pH; indicating the presence of low variation among genotypes for fruit juice pH. The magnitude of genotypic variances was higher than their corresponding environmental variances for all the traits except for unmarketable yield. This indicates that the genotypic component of variation was the major contributor to total variation in the studied traits. The results showed the potential variation existed among genotypes in all the traits except fruit juice pH. According to Engida Tsegaye *et al*. (2007), traits that showed the different genotypic and phenotypic values indicate the presence of variation among genotypes for the traits used.

4.3.2. Estimates of genotypic and phenotypic coefficient of variation

Phenotypic (PCV) and genotypic (GCV) coefficients of variations are presented in Table 4.6. Titratable acidity had the highest GCV and PCV (38.38 and 40.54), followed by average single fruit weight (34.68 and 36.63), physiological weight loss (25.67 and 27.73), plant height (24.92 and 25.42) and number of cluster per plant (22.95 and 25.17). These traits showed smaller difference between GCV and PCV, indicating the presence of minor environmental influences on the expression of these traits. The results also indicate the presence considerable genetic variability among the tested tomato genotypes. High GCV indicates the presence of exploitable genetic variability for the traits, which can facilitate selection (Yadav *et al*., 2009). Medium GCV and high PCV were observed for number of fruits per cluster (19.33 and 20.49), marketable yield (18.28and 21.38), total yield (18.60 and 21.51), Unmarketable yield (13.52 and 21.39) and firmness (17.28 and 23.14) indicated influence of the environment in the expression of the trait. However, genotypic and phenotypic coefficients of variability were medium for total soluble solid (16.3 and 17.73), fruit diameter (15.43 and 16.04), number of flower per cluster (15.19 and 16.95),

number of secondary branch (14.20 and 15.37), fruit length (11.70 and 12.12) and number of primary branch (11.19 and 13.28).

However, genotypic and phenotypic coefficients of variability were low for fruit juice pH (5.15 and 5.65), days to first harvest (5.64 and 6.10), days to 50% flowering (6.51 and 7.14), juice content (7.49 and 7.89) and fruit set percentage (7.59 and 9.076). Similar results were reported by Pradeepkumar *et al*. (2001) for most of the characters i.e. Plant height, average single fruit weight, total yield per hectare, and days to first harvest showed high PCV and GCV values. Mohanty (2003) also found high GCV and PCV for number of fruits per plant and average weight of fruits per plant. High GCV value of characters suggest that the possibility of improving these trait through selection. Similarly, high GCV and PCV were also reported by Golani *et al.* (2007) for fruits weight and number of cluster per plant. Moreover, Mehta and Asati (2008) obtained high GCV and PCV for single fruit weight per plant, number of clusters per plant, fruit firmness, plant height and physiological weight loss. Additionally, Saravanan *et al*. (2019) reported that the genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were found higher for average single fruit weight and plant height which suggested prevalence of greater phenotypic and genotypic variability among the accessions.

Difference between PCV and GCV was relatively small for most of the traits, implying that genotype contributed more than environment in the expression of these characters; and selection based on phenotypic values is therefore feasible. The difference between PCV and GCV values was relatively high for Unmarketable yield, fruit firmness, and total yield, number of cluster per plant and titratable acidity indicating greater influence of the environment in the expression of the traits. However, this difference was low for juice content, fruit juice pH, fruit length, days to first harvest, plant height and fruit equatorial diameter suggesting minimal influence of environment on the expression of the characters and possibility to improve these characters/traits.

4.3.3. Estimation of broad-sense heritability and genetic advance

In the present study, estimates of heritability in broad sense ranged from 39.3 % for UN marketable yield to 96.12 % for plant height (Table 4.6). According to Singh (2011), if heritability of a character is very high, 80% or more, selection for such characters could be

feasible. This is because there would be a close correspondence between the genotype and the phenotype due to the relative small contribution of the environment to the phenotype. However, for characters with low heritability, 40% or less, selection may be considerably difficult or virtually impractical due to the masking effect of the environment. Considering this benchmark, heritability estimate was very high (>80%) for plant height (96.12%), fruit length (93.30%), fruit equatorial diameter (92.56%), juice content (89.93%), fruit weight (89.66%), titratable acidity (89.63%), number of fruit per cluster (88.99%), physiological weight loss (85.70%), fruit juice PH (85.63%), days to first harvest(85.49%), number of secondary branches (85.34%), total soluble solids (TSS) (84.28%), number of cluster per plant (83.13%), days to 50% flowering(82.91%) and number of flower per cluster (80.33%). It was moderate (40-80%) for total yield (74.79%), marketable yield (73.09%), number of primary branches (71.05%), fruit set percentage (70.16%) and firmness (55.77%). However, unmarketable yield (39.93%) was low heritability. Characters with low heritability, selection may be considerably difficult or virtually impractical due to the masking effect of the environment.

Most of the characters had higher heritability estimates, indicating lesser influence of environment on them. The high heritability estimates obtained may be due to the divergent genotypes included in the study. The present result is in harmony with the finding of Hidayatullah *et al.* (2008) who reported high heritability for plant height, number of fruits per plant, fruit weight per plant, fruit length, fruit diameter, single fruit weight and Total soluble solid. Similarly, Pradeepkumar *et al*. (2001) reported high heritability estimates for all characters studied. Mehta and Asati (2008) also found high heritability in broad sense for plant height, number of fruits per clusters, weight of fruits, number of cluster per plant and total soluble solid.

Genetic advance under selection (GA) refers to improvement of characters in genotypic value for the new population compared with the base population under one cycle of selection at a given selection intensity (Singh, 2011). The estimate of genetic advance as percent of mean was highest for titratable acidity (74.96%) and average single fruit weight (67.76%). These results indicate that the variation existed among genotypes is due to their genetic differences and possibility of improvement of these traits through selection of parents from the tested genotypes. Similarly, Rajasekha *et al*. (2013) reported that high genetic GAM was observed for titratable acidity and average single fruit weight. It was

moderate (30-60%), for plant height(50.41%), physiological weight loss(49.03%), number of cluster per plant(43.16%), number of fruits per cluster(37.62%), total yield(33.19%), marketable yield(32.23%), total soluble solid(30.87%) and fruit diameter(30.62%). The least GAM was recorded for number of flower per cluster (28.09%), number of secondary branches (27.06%), fruit firmness (26.62%), fruit length (23.32%), number of primary branches (19.47%), un marketable yield (17.62%), juice content (14.64%), fruit set percentage (13.11), days to 50% flowering (12.22%), days to first harvest (10.75%) and pH (9.75%).

Genetic advance is the measure of improvement that can be achieved by practicing selection in a population. According to Johnson *et al*. (1955), high heritability estimates along with the high genetic advance is usually more helpful in predicting gain under selection than heritability estimates alone. Selection for the traits having high heritability coupled with genetic advance is likely to accumulate more additive genes leading to further improvement of their performance (Mahesh, 2015).

Based on the present results, the traits with high heritability estimates coupled with high values of genetic advance as percent of mean observed for titratable acidity and average single fruit weight, indicate that these are governed by additive gene action and therefore provides the most effective condition for selection. High estimates of heritability coupled with moderate genetic gain as percent of mean was observed for plant height, physiological weight loss, number of cluster per plant, number of fruits per cluster, total yield, marketable yield, total soluble solid and fruit diameter. On the other hand, lowest GAM and high heritability was observed for number of flower per cluster, number of primary branches, number of secondary branches, fruit length, juice content, fruit set percentage, days to 50% flowering, days to first harvest and pH. These results indicate the influence of non-additive gene action and considerable influence of environment in the expression of these traits. Therefore, these traits could be exploited through manifestation of dominance and epistatic components through heterosis. The characters showing high heritability with low genetic advance indicated that these traits are governed by non-additive gene action.

Table 4. 6 Estimation of genetic parameters for agronomic and quality traits of 17 genotypes tested in Kobo district during the 2021 irrigation season

N Characters	Ranges	Mean ± SEM	σ2g	σ2e	σ2p	GCV (%)	PCV (%)	H2 (%)	GA	GAM (%)
DFL	42.333-54.333	47.03±1.39	9.36	1.93	11.29	6.51	7.14	82.91	5.75	12.22
DFH	71.333- 88.667	80.53±1.87	20.60	3.50	24.10	5.64	6.10	85.49	8.66	10.75
PHT	53.467 -106.733	71.8±3.59	320.23	12.91	333.14	24.92	25.42	96.12	36.19	50.41
NPB	3.9000-6.8667	5.36±0.38	0.36	0.15	0.51	11.19	13.28	71.05	1.04	19.47
NSB	7.5000 -13.3667	10.1±0.59	2.06	0.35	2.41	14.20	15.37	85.34	2.73	27.06
NCPP	11.413-28.110	17.88±1.85	16.83	3.42	20.25	22.95	25.17	83.13	7.72	43.16
NFIPC	3.6633-7.1100	5.32±0.40	0.65	0.16	0.81	15.19	16.95	80.33	1.49	28.09
NFrPC	2.4133 -5.7267	4.16±0.28	0.65	0.08	0.73	19.33	20.49	88.99	1.56	37.62
FSP	64.334 -88.412	78.11±3.87	35.13	14.94	50.07	7.59	9.06	70.16	10.24	13.11
MY	24.728 -59.623	42±4.66	58.91	21.69	80.61	18.28	21.38	73.09	13.54	32.23
UMY	8.783-24.620	16.07±2.66	4.72	7.10	11.82	13.52	21.39	39.93	2.83	17.62
TY	28.403- 67.442	50.11±5.41	86.89	29.29	116.18	18.60	21.51	74.79	16.63	33.19
FL	45.933 -70.867	55.52±1.74	42.22	3.03	45.26	11.70	12.12	93.30	12.95	23.32
FD	38.0-63.533	49.26±2.15	57.76	4.64	62.40	15.43	16.04	92.56	15.08	30.62
FW	40.65- 125.58	76.14±8.97	697.44	80.39	777.83	34.68	36.63	89.66	51.59	67.76
PWL	10.367-25.301	17.91±1.88	21.14	3.53	24.67	25.67	27.73	85.70	8.78	49.03
PH	3.8633- 4.8600	4.15±0.09	0.05	0.01	0.05	5.15	5.56	85.63	0.41	9.83
TSS	2.4667-5.4000	4.1±0.29	0.45	0.08	0.53	16.30	17.76	84.28	1.27	30.87
JC	70.277 -93.330	84.23±2.11	39.75	4.45	44.20	7.49	7.89	89.93	12.34	14.64
TA	0.1160 -1.2607	0.74±0.10	0.08	0.01	0.09	38.38	40.54	89.63	0.55	74.96
Frm	3.278- 7.260	5.45±0.84	0.89	0.70	1.59	17.28	23.14	55.77	1 .45	26.62

Note:$\sigma^2 e = environmental\ varation$; $\sigma^2 g$ = Genotypic variance; $\sigma^2 p$ = phenotypic variance; PCV= phenotypic coefficient of variance; GCV= genotypic coefficient of variance; $H^2 b$= heritability; GA= genetic advance and GAM= genetic advance as percent of mean.

4.4. Correlation Analysis

Correlation coefficients of different traits considered are presented in Table 4.7. Days to 50% flowering showed positive and significant genotypic and phenotypic correlation with days to first harvest and fruit juice pH. It showed negative and significant genotypic and phenotypic correlation with marketable yield, total yield, fruit diameter, juice content and titratable acidity. Days to first harvest exhibited positive and significant genotypic and phenotypic correlation with days to 50% flowering and negative and significant genotypic and phenotypic correlation with marketable yield, total yield, fruit diameter, juice content and titratable acidity. Similarly, Mehta and Asati (2008) reported that days to 50% flowering had positive association with days to first harvest and negative correlation with number of fruits per cluster and number of fruits per plant.

Number of primary branches per plant exhibited a significant positive association with number of secondary branches, number of cluster per plant, number of flower per cluster, number of fruit per cluster and marketable yield per hectare. In line with the present results, Ghosh *et al*. (2010) reported that number of branches per plant had positive correlation with number of flowers per plant, number of fruit per cluster and marketable yield per hectare. Number of flowers per clusters had significant positive correlation with number of fruit cluster per plant and marketable yield. Number of fruit clusters per plant had a significant positive correlation with fruit set percentage and marketable yield. The present results are in agreement with the findings of Haydar *et al*., 2007 who reported that number of fruits per plant was positively correlated with fruit weight per plant. Similarly, Ghosh *et al*. (2010) demonstrated positive association of number of fruits per cluster with number of fruit clusters per plant, number of fruits per plant and fruit yield per plant and number of fruit clusters per plant with number of fruits per plant.

Average single fruit weight exhibited positive and significant relationship with fruit marketable yield, total yield total soluble solid juice content and titratable acidity (Table 4.7). Fruit length had significant positive correlation with days to 50% flowering, days to first harvest, marketable yield and total yield. Fruit diameter showed significant positive correlation with marketable yield unmarketable yield, total yield, juice content and titratable acidity. Similarly, Haydar *et al.* (2007) reported that fruit length was positively correlated with fruit diameter, single fruit weight and pericarp thickness.

Marketable yield per hectare had positive and significant genotypic and phenotypic correlation with number of primary branches, number of secondary branches, number of clusters per plant; number of flowers per cluster; number of fruits per cluster, fruit set percentage, single fruit weight, fruit diameter, fruit length, total yield, juice content, fruit juice PH and titratable acidity (Table 4.7). These results indicate that genotypes with higher number of primary branches, number of secondary branches, number of clusters per plant; number of flowers per cluster; number of fruits per cluster, fruit set percentage, single fruit weight, fruit diameter and fruit length give high marketable fruit yield and therefore, plants having higher number of these parameters will indirectly be selected for high marketable fruit yield (Table 4.7). Similarly, Meseret Degefa *et al*. (2012) reported highly significant positive correlation of marketable yield per hectare with most of the parameters. It showed negative and significant genotypic and phenotypic correlation with days to 50% flowering and days to first harvest. Moreover, positive and significant association of pairs of characters at phenotypic and genotypic level justified the possibility of correlated response to selection. The negative correlations may prohibit the simultaneous improvement of those traits.

Table 4.7 Estimation of genotypic (above diagonal) and phenotypic (below diagonal) correlation coefficient for 21 characters in 17 tomato genotypes Kobo district in 2021/222

Characters	DFL	DFH	Pht	NPB	NSB	NCPP	NFlPC	NFrPC	FSP	MY	UMY	TY	FL	FD	FW	PWL	PH	TSS	JC	TA	Frm
DFL	1	0.90**	0.33ns	-0.18ns	-0.23ns	-0.09ns	0.01ns	-0.13ns	-0.35ns	-0.71**	-0.22ns	-0.75**	0.46ns	-0.55*	-0.44ns	0.13 ns	0.53*	-0.22ns	-0.62**	-0.64**	-0.31
DFH	0.77**	1.00	0.17ns	-0.33ns	-0.36ns	-0.13ns	-0.12ns	-0.26ns	-0.38ns	-0.66**	-0.15ns	-0.69**	0.55ns	-0.50*	-0.41ns	0.07 ns	0.47 ns	-0.08 ns	-0.57**	-0.53**	-0.30 ns
Pht	0.330*	0.24ns	1	0.75**	0.28ns	0.14ns	0.45ns	0.32ns	-0.10ns	-0.30ns	0.17ns	-0.26ns	-0.04ns	-0.05ns	-0.05 ns	0.16 ns	-0.13 ns	0.09 ns	0.04 ns	-0.28 ns	-0.26 ns
NPB	-0.06ns	-0.11ns	0.60**	1.00	0.62**	0.40**	0.62**	0.60**	0.28ns	0.17**	0.18ns	0.20ns	-0.22ns	0.08ns	0.04 ns	0.22 ns	-0.54**	0.05 ns	0.22 ns	0.08 ns	-0.17 ns
NSB	-0.11ns	-0.27ns	0.26ns	0.62**	1.00	0.63**	0.70**	0.68**	0.30ns	0.57**	-0.14ns	0.53ns	-0.06ns	0.05ns	0.05 ns	0.20 ns	-0.63**	-0.03 ns	0.31 ns	0.42 ns	-0.25 ns
NCPP	-0.04ns	-0.02ns	0.16ns	0.28*	0.39**	1.00	0.66**	0.70**	0.35ns	0.44**	-0.58**	0.31ns	-0.12ns	-0.32ns	-0.38 ns	0.32 ns	-0.29 ns	-0.16 ns	-0.01 ns	0.28 ns	-0.26 ns
NFlPC	0.03ns	-0.20ns	0.30*	0.36**	0.58**	0.41**	1.00	0.91**	0.20ns	0.19**	-0.21**	0.13ns	0.15ns	-0.23ns	-0.24 ns	0.29 ns	-0.48*	0.03 ns	0.06 ns	0.02 ns	-0.56 **
NFrPC	-0.13ns	-0.29*	0.22ns	0.39*	0.59**	0.48**	0.89**	1	0.58**	0.31**	-0.13ns	0.28ns	0.09ns	-0.13ns	-0.12 ns	0.19 ns	-0.53*	0.03 ns	0.10 ns	0.16 ns	-0.47 ns
FSP	-0.29ns	-0.26ns	-0.06ns	0.21ns	0.20ns	0.24ns	0.001ns	0.45**	1.00	0.37**	0.17ns	0.41ns	-0.10ns	0.14ns	0.18 ns	-0.10 ns	-0.39*	0.08 ns	0.16 ns	0.39 ns	0.04 ns
MY	-0.55**	-0.41**	-0.19ns	0.57**	0.48**	0.35*	0.56**	0.9**	0.24**	1.00	-0.07ns	0.98**	0.29**	0.54**	0.46**	-0.27 ns	-0.63**	0.30 ns	0.71**	0.93**	0.02 ns
UMY	-0.12ns	-0.03ns	0.09ns	0.08ns	-0.13ns	-0.25ns	0.05ns	0.03ns	-0.02ns	-0.17ns	1.00	0.15ns	-0.18ns	0.57**	0.54 ns	-0.30 ns	-0.13 ns	0.26 ns	0.26 ns	0.03 ns	-0.04 ns
TY	-0.57**	-0.42**	0.37ns	-0.01ns	0.23ns	0.28**	0.03ns	0.09ns	0.25ns	0.97**	0.08	1.00	0.34**	0.67**	0.58**	-0.34 ns	-0.63 ns	0.35 ns	0.76**	0.93*	0.01 ns
FL	0.29**	0.43*	-0.05ns	-0.26ns	-0.10ns	-0.13ns	0.10ns	0.06ns	-0.07ns	0.33**	-0.13	0.41**	1.00	-0.22ns	-0.04 ns	-0.20 ns	-0.11 ns	0.17 ns	-0.24 ns	-0.24 ns	-0.28 ns
FD	-0.48**	-0.40**	-0.06ns	-0.01ns	0.03ns	-0.29*	-0.18ns	-0.12ns	0.08ns	0.45**	0.30**	0.54**	-0.10ns	1	0.96 ns	-0.77 **	-0.34 ns	0.48 ns	0.82**	0.60*	0.10 ns
FW	-0.37ns	-0.32**	-0.05ns	-0.06ns	0.03ns	-0.36**	-0.18ns	-0.11ns	0.11ns	0.88**	0.77ns	0.55**	0.07ns	0.93**	1.00	-0.85 **	-0.36 ns	0.47*	0.77**	0.55*	0.12 ns
PWL	0.07ns	-0.03ns	0.10ns	0.11ns	0.14ns	0.26ns	0.26ns	0.21ns	-0.04ns	-0.26ns	-0.07ns	-0.29*	-0.19ns	-0.66**	-0.69**	1.00	0.10 ns	-0.49 ns	-0.58**	-0.37 ns	-0.05 ns
PH	0.40**	0.37**	-0.10ns	-0.25ns	-0.37**	-0.14ns	-0.36**	-0.44**	-0.30**	-0.42**	-0.07ns	-0.43**	-0.10ns	-0.27ns	-0.29*	0.04ns	1.00	-0.54**	-0.59**	-0.62*	0.13 ns
TSS	-0.15ns	-0.08ns	0.06ns	-0.04ns	-0.01ns	-0.08ns	0.05ns	0.05ns	0.06ns	0.17ns	0.26ns	0.24ns	0.12ns	0.38**	0.39**	-0.33**	-0.40**	1.00	0.69**	0.52**	0.09 ns
JC	-0.56**	-0.47**	0.02ns	0.15ns	0.23ns	0.01ns	0.07ns	0.11ns	0.13ns	0.52**	0.18ns	0.57**	-0.19ns	0.68**	0.60**	-0.42**	-0.48**	0.50**	1.00	0.78**	0.10 ns
TA	-0.43**	-0.39**	-0.22ns	0.02ns	0.31*	0.25ns	0.02ns	0.07ns	0.13ns	0.64**	0.06ns	0.66**	-0.18ns	0.51**	0.46**	-0.33*	-0.49**	0.46**	0.60**	1.00	0.16 ns
Frm	-0.07ns	-0.13ns	-0.15ns	-0.06ns	-0.09ns	-0.13ns	-0.37**	-0.39*	-0.10ns	0.04ns	-0.10ns	0.03ns	-0.26ns	0.03ns	0.03ns	-0.10ns	0.18ns	0.14ns	-0.04ns	0.23ns	1.00

4.5. Farmers' Selection Criteria and Participatory Evaluation of Tomato Genotypes

Participatory variety selection addresses problems of farmers that are not addressed by the formal breeding system. Likewise, Thapa *et al*. (2009) and Tiwari *et al*. (2011) illustrated participatory variety selection as a desirable method to resolve problems in introduction and adoption of released varieties, in evaluation and selection for preferences of farmers for their target environments. In this regard, farmers' participation in genotypes evaluation process has a paramount role to identify farmers 'preferred traits in promoting tomato genotypes.

Discussion was held with farmers to help them in identifying selection criteria. Accordingly the following criteria were identified with their own justification:

- ✓ **Fruit yield**: Farmers' were able to compare the genotypes productivity through visual observation on the field.
- ✓ **Fruit Size**: It has been mentioned as a proxy measure for marketability.
- ✓ **Fruit color**: The color of tomato genotypes highly matters in determining its market price and demand.
- ✓ **Fruit Shape**: This criterion highly matters on the tomato genotypes for market preference.
- ✓ **Diseases resistance:** used as varieties tolerant or resistant to pests and diseases.

The next step was to rank the criteria so as to easily prioritize each criterion for the selection process. Productivity, market preference and diseases resistance were found to be the top three priorities of tomato genotypes evaluation by the farmers (Table 4.7).

Farmers' perception on the performance of tomato genotypes were tested and analyzed using matrix and pair wise ranking. All the evaluated genotypes preformed well as compared to the local varieties. After discussion and debates, farmers ranked the genotypes based on their preference and degree of satisfaction by giving the values 1-5 (Boef and Thijssen, 2007). That is; 1=Very Good; 2= Good; 3= Medium; 4= Poor; 5=Very poor, this values indicates that genotypes recording the highest scores were lowest preferred by farmers. On the other hand, genotypes recording the lowest scores were more preferred by farmers.

The overall mean of the ranks for all performance based on farmers identified criteria were lower for Metadel (65), Chali (74.5), Eshet (83) and Cochiro (108). This means farmers have better preference towards these genotypes as compared to others (Appendix Table 2). Farmers were also given chance to compare each variety to the other ones with regards to the values based on identified criteria. Pair wise ranking was used as a tool to summarize farmers' preference toward the genotypes (Boef and Thijssen, 2007). The result showed that Metadel was the most preferred genotypes followed by Chali, Eshet and Cochiro (Appendix Table 2). Farmers indicated that Metadel and Chali were selected due to their productivity, fruit size, fruit color and moderately resistance to pest. Cochiro and Eshet genotype had the lowest scores due to its fruit yield, fruit shape, fruit size, moderately resistance to pest and market preference.

On the other hand, genotypes which have less preference by the farmers were due to scoring high value of the criteria. However, Miya genotype was found to be least preferred by farmers in the area although it recorded higher fruit yield under field trial. This indicates that farmers have their own preferences rather than the yield performances of the genotype. Besides, farmers selection criteria vary and highly dependent on the needs of individual farmers. Sembersa local and Sirinka-1 genotypes were less preferred by farmers on the basis fruit yield; disease resistance and market preference.

The results are in agreement with the findings of Mohammed Beriso and Yonas Worku (2016) who reported that Metadel and Chali was the most preferred followed by Cochiro and Melka Salsa. In line with this finding, Seifudin Mehadi (2013) stated the overall farmers' preferences indicated that Miya genotype was least preferred by farmers from eight tomato genotypes evaluated at Delo Mena and Barbare districts of Bale zone, South-Eastern Ethiopia. On the contrary, to the present result, Tewodros Mulualem and Negasi Tekeste (2014) stated that Melka Shola and Miya genotypes were selected as top ranking or adapted genotypes by farmers' selection. Generally, the genotypes that showed better agronomic performance was also relatively accepted from farmers' evaluation perspectives.

Table 4.8 Pair-Wise Ranking of Farmers Selection Criteria (n=20) Used for Evaluation of Tomato Genotypes in Kobo District the 2021 Irrigation Season

No	Selection criteria	FY	FS	F. size	FC	DR	Total	Rank
1	FY	X	FY	FY	FY	FY	4	1
3	FS		X	FS	FS	DR	2	3
4	F. size			X	FC	DR	0	5
5	FC				X	DR	1	4
6	DR					X	3	2

Note: FY = Fruit Yield; FS = Fruit Shape; F. size = Fruit size; FC = Fruit color; and DR = Disease Resistance.

4.5.1 The comparison of farmer's selection and field performance on the tested tomato genotypes

The rank of farmer's selection and field performances of the tested tomato genotypes are presented in Table 4.8; which showed that researcher's rank did not coincided with farmer's rank. This difference was due to the fact that farmers have their own preferences rather than the field performances of the genotypes. These results were in agreement with the finding of Bellon (2012) stated that farmers' perception about crop varieties are not always the same as researchers. The reasons behind farmers' preferences of Metadel genotype is attributed to its fruit size; fruit shape; fruit yield, market preference and resistance to pest.

Table 4.9. Ranking of Genotypes According to Farmers Evaluation and Field Performance

Genotypes	Field performance rank based on yield	Farmer's evaluation rank
Gelila	10th	14th
Eshet	2nd	3rd
Gelilema	14th	10th
Sembersa	17th	17th
M. shola	6th	13th
ARP D2	5th	9th
Sirinka	15th	15th
Miya	7th	16th
Mersa	16th	12th
Fetan	9th	11th
Cochiro	12th	5th
Metadel	3rd	1st
Roma VF	13th	4nd
Bishola	8th	7th
Chali	1st	2th
Woyno	11th	6th
M. salsa	4th	8th

Chapter 5. CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

In the present study, tomato genotypes were evaluated under irrigation condition for their variability and performance for growth, yield and quality parameters in Kobo district. The results indicated the presence of considerable variability among tested genotypes, suggesting the possibility of further improvement through selection. Significant performance difference was recorded among genotypes for growth, yield and quality parameters; and Chali (59.62 t/ha), Eshet (51.95 t/ha), and Metadel (51.12 t/ha) were identified as most promising tomato genotypes for their marketable fruit yields and fruit quality such as juice content, fruit juice pH and titratable acidity. Suggesting the importance of these genotypes for commercial production and processing industries. From the correlation analysis, marketable fruit yield had positive and highly significant association with number of branches, number of clusters, number of flowers per cluster; number of fruits per cluster, fruit set percentage, single fruit weight, juice content, fruit juice pH and titratable acidity, indicating the possibility of simultaneous improvement of marketable yield through indirect selection using these parameters. From the participatory evaluation, Metadel, Chali, Eshet and Cochiro were selected by the farmers.

5.2. Recommendations

The present findings showed that most of the tested tomato varieties are suitable for Kobo district to improve tomato production and the incomes of smallholder farmers. Therefore, Chali, Eshet, Melkasalsa, Metadel, and ARP D2 tomato genotypes can be recommended for their promising marketable yields for small scale farming in the study area. In addition, Chali, Eshet, Gelila and Metadel genotypes can also be recommended for commercial production and processing industry for their fruit quality parameters. Furthermore, to develop a forceful recommendation, it is advisable to repeat the experiment on different sites and years.

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APPENDICES

Appendix Table 1. Matrix ranking of tomato genotypes for selected traits and final acceptability rank

Genotypes	FY	FS	F. size	FC	DR	Total	Rank
Relative weight	**1**	**5**	**4**	**3**	**2**		
Gelila	1	65	64	48	24	202	14
Eshet	2	5	12	30	34	83	3
Gelilema	6	30	32	36	20	124	10
Sembersa	16	75	68	42	22	223	17
M. shola	17	35	60	18	32	162	13
ARP D2	14	20	44	12	30	120	9
Sirinka	13	70	52	42	28	205	15
Miya	12	80	56	51	14	213	16
Mersa	7	50	48	45	10	160	12
Fetan	11	60	16	21	18	126	11
Cochiro	5	85	4	6	8	108	5
Metadel	3	45	8	3	6	65	1
Chali	4	25	20	9	16	74	2
Bishola	15	15	24	33	26	113	7
Roma VF	8	10	40	27	12	97	4
Woyno	9	40	40	24	4	117	8
M. salsa	10	55	28	15	2	110	6

A B C

Appendix figure 1 A, Seedling on nursery, B, Seedling transplanting time, C, Performance of tomato genotypes at vegetative stage

A

B C

Appendix figure 2 A, Staking, B, Flowering stage, C, Fruit setting stage

A B

Appendix figure 3 A, Data collection , B Performance of tomato genotypes at harvesting stage

Appendix figure 4 Participatory evaluation of tomato genotypes at field stage

Appendix figure 5 Measuring different parameters in laboratory

BIOGRAPHY

The author, Mesfin Kebede, was born in 29 July 1979 E.C in Raya Kobo District North wollo zone in the Amhara National Regional State, Ethiopia. He attended elementary education (grade 1-8) at kobo Ewuket Chora Elementary School from 1992-1996. After completing elementary education, he was enrolled at Kobo Secondary high School and preparatory, where he pursued and completed his Secondary Education from 1997-2000 (grade 9-12). Then he joined Adama University , Asela campus College of Agriculture 2001-2003 and graduated with Horticulture department. Up on graduation; he was employed in Office of Agriculture in Raya Kobo district wereda expert from 2004-2011. Then; he joined the School of Graduate Study of Bahirdar University, college of Agriculture and Environmental Sciences in 2012 regular Program to pursue a study leading to the Degree of Master of Sciences in (Horticulture).