International Journal of Research in Agriculture and Forestry
Volume 7, Issue 6, 2020, PP 01-11
ISSN 2394-5907 (Print) & ISSN 2394-5915 (Online)

Proportional Enactment of Tomato (*Solanum Lycopersicum L. Mill*) Varieties under Greenhouse Production Systems of Tigray Biotechnology Center, Ethiopia

Tsehaye Kidus*, Tekestebrhan Areya and Wendwesen Tesfay

Tigrai Biotechnology Center, Mekelle, Ethiopia

***Corresponding Author:** Tsehaye Kidus, Tigrai Biotechnology Center, Mekelle, Ethiopia*

ABSTRACT

The experiments were conducted at Tigray Biotechnology center to assess certain five Tomato (Lycopersicon esculentum Mill.) varieties for their growth, development and yield under modern and automatically controlled Greenhouse condition. The experiment was established using Completely Randomized Design (CRD) with three replications and Data was subjected to analysis of variance (ANOVA) and treatment means were compared using least significant difference (LSD). Five Tomato varieties Chali, Cochoro, Fetan and Melkasalsa and Melkashola were used for the experiment. Data were collected on growth parameters of the five tomato varieties on plant height, fruit number, fruit girth, flowering days, root length, germination percentage and total fruit yield. The results shows that growth parameters of the varieties had significantly ($p \leq 0.05$) affected. Significantly the highest germination percentage (92.63%), plant height (87.4 cm), root height (60.667 cm), early flowering day (31 cm) and total fruit yield (1688.6 Kg) was recorded from variety Melkasholla. Significantly the highest fruit number per plant (30.27) and Fruit girth per plant (65.5 mm) was recorded from tomato variety chali and Fetan respectively. The tomato variety Melkasholla was found suitable and loftier as related to other tomato varieties with respect to germination percentage, plant height, root length, early flowering day and total fruit yield under the modern Polycarbonate type greenhouse. Chali and Fetan tomato varieties were similarly found superior with respect to number of fruit per plant and Fruit girth per plant on modern Polycarbonate type greenhouse respectively and therefore it is recommended that tomato producers around Ethiopia can use Melkasholla, Chali and Fetan tomato varieties for decent quality tomato production under greenhouse.

Keywords: *Growth parameters, polycarbonate, Greenhouse, Tomato variety*

INTRODUCTION

Tomato (*Lycopersicon esculentum Mill*) belongs to the family Solanaceae and is one of the most widely eaten vegetables in the world which popularly stems from the fact that they can be eaten fresh or in multiple of processed forms (Willcox *et al*.,2003, sharoni and Levi,2006). It has been reported that consumption of raw tomato and tomato based products is associated with reduced risk of cancer and cardiovascular disease(Giovannucci *et al*.,2002).Tomato contains phenolic compounds, lycopene, phytochemicals which have high antioxidant ability and free radical scavenging ability to inhibit the enzymes responsible for oxidative stress imposed by Reactive Oxygen Species (ROS) production (Kähkönen *et al*.,2001).Cultivated tomato is related to wild tomatoes originating from Peru, Ecuador and other parts of South America including the Galapagos Islands. The centre of its domestication and diversification is Mexico (Rick, 1978; Peralta *et al*., 2008). Wild relatives of tomato and intermediate forms (landraces or creoles) harbour a wealth of genetic diversity and are important sources of genetic material in crop improvement and conservation programmes (Sánchez-Peña *et al*., 2006). Tomato ranks 1st with respect to world vegetable production and accounts for 14% (over 100 Mt year-1) $1.6 billion market (Bauchet and Causse, 2010). The world production of tomato figure in 2012 was 145.8 metric tonnes with China leading with 41.9 metric tonnes. In Africa, Egypt is the leading producer with the production of 39.5 metric tonnes and However, average yield of tomato in Ethiopia is low, ranging from 6.5-24 metric tonne/ha (Gemechis *et al*., 2012) as equated with average yields of 51, 41, 36 and 34 metric tonne/ha in America, Europe, Asia and the entire world, correspondingly (FAOSTAT, 2010).

In Ethiopia tomato is one of the most important and widely grown vegetable crops, both during

the rainy and dry seasons for its fruit by smallholder farmers, commercial state and private farms (Gemechis *et al*., 2012; MoA., 2013; Emana *et al*., 2014). In 2008,tomato production in Ethiopia reaches about 41,815 tones from a total harvested area of 3542 ha (FOA,2009).The total production of tomato in Ethiopia has shown a marked increase, indicating that it has become the most profitable crop providing a higher income to smallholder farmers compared to other vegetable crops (Lemma *et al*., 2003). Greenhouse-controlled environment technology was traditionally developed to extend the crop cycle into seasons that are too harsh to produce crops in open fields. The technology has focused on optimizing environmental conditions to maximize yield as well asproduct quality. Contributions to yield increases were generally made by technological advancements in controlling environment as well as breeding cultivars suitable for greenhouse production. For tomato (*Solanum lycopersicum*), the annual greenhouse tomato yield has reportedly doubled from 30 kg·m–2 to 60 kg·m–2 in The Netherlands (Higashide and Heuvelink, 2009). Tomatoes are the leading greenhouse vegetable crop in the United States and Canada. In the U.S. the total acreage in greenhouse tomato production increased by 40 percent between 1996 and 1999.Statistics for 1999 show that the U.S. had about 800 acres in greenhouse vegetable production, with tomatoes accounting for 750 of those acres (Snyder and Richard, 1995).Greenhouse vegetable production is the most energy-intensive agricultural sector. Energy cost in greenhouses is between 20-40% of the total cost. For instance, Djevic and Dimitrijevic (2009) reported an energy use of 9.76 MJ/m^2 for multi-span greenhouse, and 13.93 MJ/m^2 for the tunnel type. Moreover, the average energy productivity of tomato is about 0.01 ton/GJ, this means that 0.01 units output was obtained per unit energy (Pahlavan *et al.*, 2011).

Even though greenhouse vegetable production is energy intensive however contemporary green houses which are equipped with finned pipe roof cooling system, alternative heating systems, fog system, multi-layer thermal screens, heat pump, heat storage tank and fully automated irrigation, and fertilization control are available in Tigray Biotechnology Center growing tomatoes in such greenhouse extend the season by providing protection from frost and maintaining warmer temperatures that allow for earlier harvest. Greenhouses also provide a protected growing environment for plants which increases the potential for higher yields and more uniform fruit. The objective of the study was to examine and compare the performance of five tomato cultivars commonly grown in Ethiopia with respect to growth, fruit yield and quality when grown under modern temperature and hu midity control greenhouse system in Tigray Biot echnology Center, Mekelle, Tigray, Ethiopia.

Variety	Altitude	Growth habit	Unique character	Utilization	Maturity days	Research yield (Q/ha)
Fetan	700-2000	Determinate	Early maturing and concentrated fruit yield	Fresh	78-80	454
Chochero	700-2000	Semi-determinate	Round fruit shape, green shoulder fruit color before mature	Processing	75-90	350
Melkashola	700-2000	Determinate	Globular fruit shape	Processing	100-120	430
Chali	700-2000	Determinate	Round fruit shape	Processing	110-120	300
Melkasalsa	700-2000	Determinant	Small fruit size, Slightly cylindrical fruit shape	Processing	100-110	320

Source: *Meseret et al., (2012)*

MATERIALS AND METHODS

Description of the Study Area

The study were conducted at the Tigray Biotech nology Center PLC (TBC) modern greenhouse is located at the Northern part of Ethiopia in Me kelle,Tigray Regional State which is located 789 km North of Addis Ababa at an altitude of 2021 meter above sea level, $13^0$30' 0" N latitude and $39^0$28'11"E longitudes (MARC, 2012). Average maximum and minimum temperatures of the greenhouse 26.2°C and 11.3°C, respectively and average maximum and minimum relative humidity of 91.40 and 37.92%, respectively.150 0 m^2 (50m x 30m) Polycarbonate type greenhouse were used (Figure.1).

Figure1. *Polycarbonate type greenhouse*

Experimental Materials

The Following Five tomato varieties commonly gr own in Ethiopia were used in the experiment, the fourare determinate type (Cochoro, Fetan, Melkasola and Melkasalsa) while the other one is semi-determinate type Chali. The seeds of all the varieties were obtained from the collections preserved at Tigray Agricultural Research Center (TARI).

Experimental Design and Treatments

Seeds of the five varieties were sown in pro trays with 98 cell using 100 % coco peat which contains good texture (PH of 5.6 and TDS 0.00ppt) in a greenhouse. As soon as the first two true leaves were abundantly established, foliar fertilizer (DAP 3 g/L RO water) was applied once a week followed by the Seedlings were watered once a day with water cane using Reverse Osmosis water. Seedlings with 7-10 cm in height with good sturdy were transplanted by hand on the selected greenhouse which is 40 days after seeding. While, substrate used for transplanting and cultivation is a mixture of 40% forest soil, 30% red ash (fertile soil), 20% sand, and 10% Manure. The bed was prepared using a labor and overhead irrigation systems were used on the greenhouse. Half of the nitrogen source 25kg urea on the entire experimental site was applied at transplanting and the remaining half was applied during active stage of vegetative growth which is 4 weeks after transplanting while recommended rate which is 25 kg of DAP (Di ammonium phosphate) were applied at planting time and at flowering stage along the planting row. All other fertilizers were applied as recommended rate which is set in (Table 1) and all cultural practices were performed uniformly to all tomato varieties which are found in the plots.

Table1. *Nutrient recommendation*

Crop	N	P	K	Ca	Mg
Concentration in mg/l					
Tomato varieties	190	40	300	0	0

The greenhouse was 50 m long and 30 m wide with an east west direction, while each cultivatio n of plot was 49m long and 20m wide with total planting area of 980m^2, and crop rows were aligned north-south. Each experiment was laid out as a randomized complete block design with 3 replications of each cultivars.1300 plants in each block and total of 6500 plants from were separately planted on the allocated blocks. Spaced 70 cm in row, 30 cm between plants within row and 60 cm spaced of walkway for overall agronomic practice like weeding and harvesting. All agronomic practice methods were taken during growth and development period of the tomato cultivars such as fertilization, agricultural chemicals spraying and others were regularly with the usual production practices on the greenhouse.

Data Collection and Analysis

Data were collected on After 51 days of transplanting and 20 samples of the growth

parameters were taken Germination rate, plant height, Root height, number of flowers, and number of fruits per plant, fruit weight per plant and fruit yield per hectare. The meter rulers was used for the measuring of the tomato plant height from base to the tip of the main shoots while the number of leaves were counted and recorded. The numbers of flowers were counted and recorded at 50% flowering. The number of fruit per plant was counted while the fruit weight per plant and fruit yield per 83.3 m^2 were weighed and recorded at harvesting. Data was subjected to analysis of variance (ANOVA) using IBM SPSS Version 20 and treatment means were compared using least significant difference (LSD) at the 5% level of significance.

Results and Discussion

Germination Rate

On the germination rate ranged from 73.3 % - 92.6 % given in (Table 1) which shows that the germination rate were varied significantly (P≤0.05) and highest significant germination percentage were recorded on Melkashola (92.9%) and the least germination rate were recorded on Fetan (72%) however, it was not significantly different from Chochero (83.3 %), Melkasalsa (83.2%), Chali (83.1%) all of which were statistically similar among each other. This result was in line with national standard minimum tomato seed germination percentage at laboratory which was ranged from 70% to 85% (ESA, 2000) and likewise agreed with the discovery of Ketema *et al.*, 2016 who have found difference (85-95.25%) in germination percentage of seven cultivars of in Jimma. Ajal, M. O., & Ajani,O. O. (2014) also reported the wide difference (40.7-95 %) of standard germination.

Table2. *Descriptive Germination rate*

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	633.900	4	158.475	52.650	.000
Within Groups	30.100	10	3.010		
Total	664.000	14			

Means represented by different letter are significantly different at p ≤ 0.05, ***Df****: Degree of freedom,* ***F:****F value,* ***LSD****: Least significant difference*

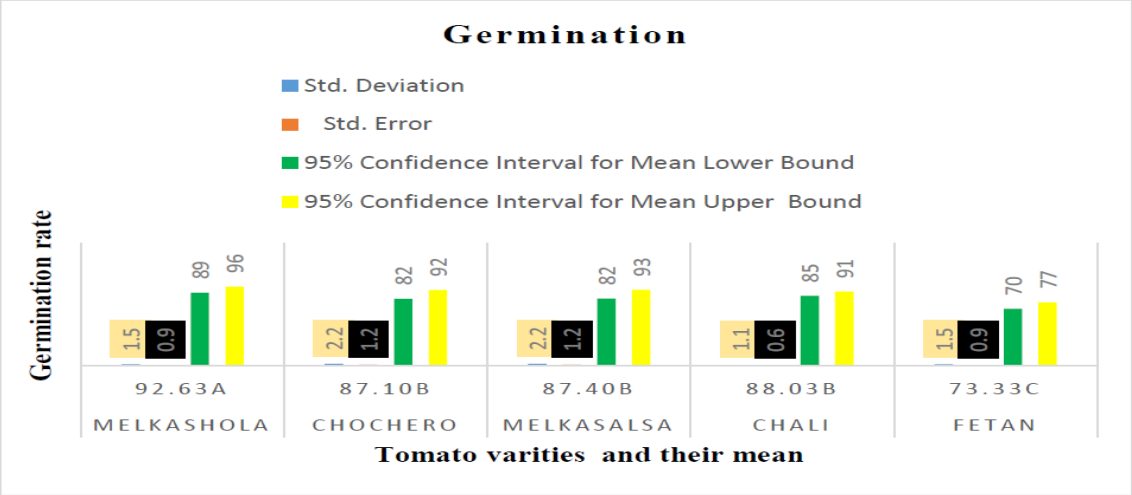

Figure2. *Germination rate of the tomato variety*

Plant Height

The response of variety to plant height per plant were varied significantly (P≤0.05) and the mean value of plant heights ranged from 71.83 - 87.40 cm.The tallest plants were recorded by Melka shola (**87.4** cm) and Chali (**84.9** cm) while the shortest plants were recorded on Melkasalsa (71.8 cm) and Chochero (75.7 cm). The plant height of the current result is in agreement with ketema *et al.*,2015 and even the author has mentioned that Melkassalsa was the shortest (39.5 cm) Hussain *et al.*, (2001) reported wide range of difference (61.6-126.5cm) in plant height among the 10 tomato genotypes evaluated in Pakistan. Similarly, Dufera (2013) obtained wide difference (51.5-129.7 cm) for plant height in tomato. Meseret *et al.* (2012), Shushay Cherenet and Haile Zibelo (2014) also obtained wide difference (40.2--107 cm) among the nine tomato varieties evaluated in western lowland of Tigray, Northern Ethiopia.

Table3. *Description Plant height*

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	3071.824	4	767.956	778.860	.000
Within Groups	9.860	10	.986		
Total	3081.684	14			

Means represented by different letter are significantly different at p ≤ 0.05, ***Df****: Degree of freedom,* ***F:*** *F value,* ***LSD****: Least significant difference*

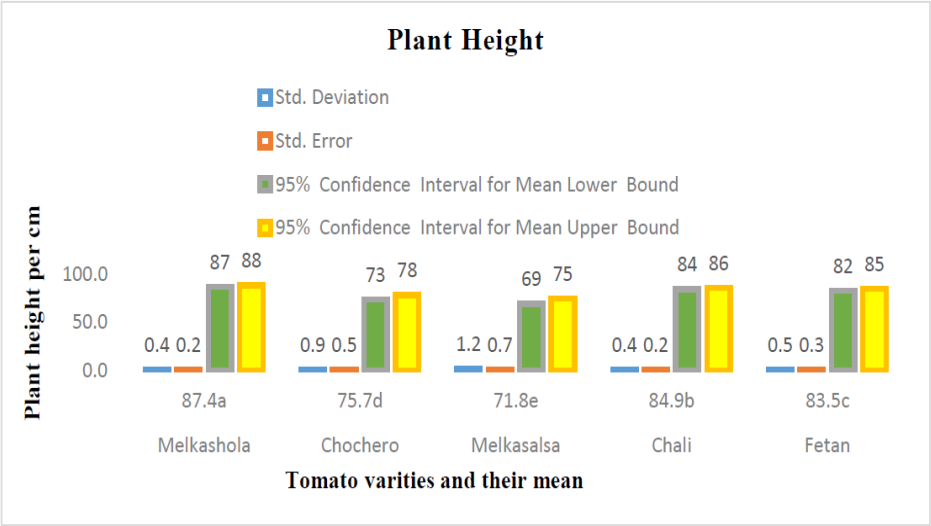

Figure3. *Plant height of the tomato varieties per cm*

Root Height

Highly significant (P≤0.05) effect was observed in the root height of the Melkashola (60.7 cm) from the other experimental tomato varieties. The other four varieties chochero, Fetan, Melkasala and Chali were found with no statically different among each other and the shortest root height were recorded on Chali (22 cm) and chochero (22.6 cm). Regarding about root height the finding were reveals wide and huge difference with the finding of Kumar (2007) who reported (6.4-6.59 cm) in the root length of tomato varieties in India and with ketema *et al.*, 2016 who reports (4.16 -13.50 Cm) in Ethiopia.

Table4. *Description root height*

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	3071.824	4	767.956	778.860	.000
Within Groups	9.860	10	.986		
Total	3081.684	14			

Means represented by different letter are significantly different at p ≤ 0.05, ***Df****: Degree of freedom,* ***F:*** *F value,* ***LSD****: Least significant difference*

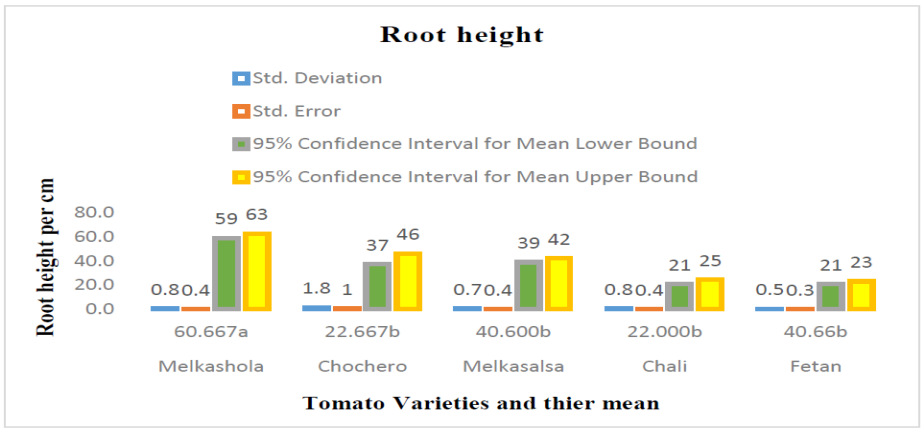

Figure4. *Root height of the tomato varieties per cm*

Flowering Days

The period among transplanting and flowering ranged from 30-35 days and the Flower number showed significant ($p \leq 0.05$) difference among the varieties (Table 2). Between the diverse varieties, Chochoro, Melkassalsa and Melkashola revealed earliest flowering and no significant difference (30- 31 days) while Fetan and chali were revealed late in flowering (34 – 35 days). The finding was in agreement with Ketema *et al.*, 2016 with flowering range (31-37 days) but has extensive difference with Meseret *et al.*,2012 and Emami *et al.*, 2012 with flowering range (38-49 days) and (103-127 days) respectively.

Table5. *Description of flowering day per variety*

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	1619.783	4	404.946	1813.190	.000
Within Groups	2.233	10	.223		
Total	1622.016	14			

*Means represented by different letter are significantly different at $p \leq 0.05$, **Df**: Degree of freedom, **F:** F value, **LSD**: Least significant difference*

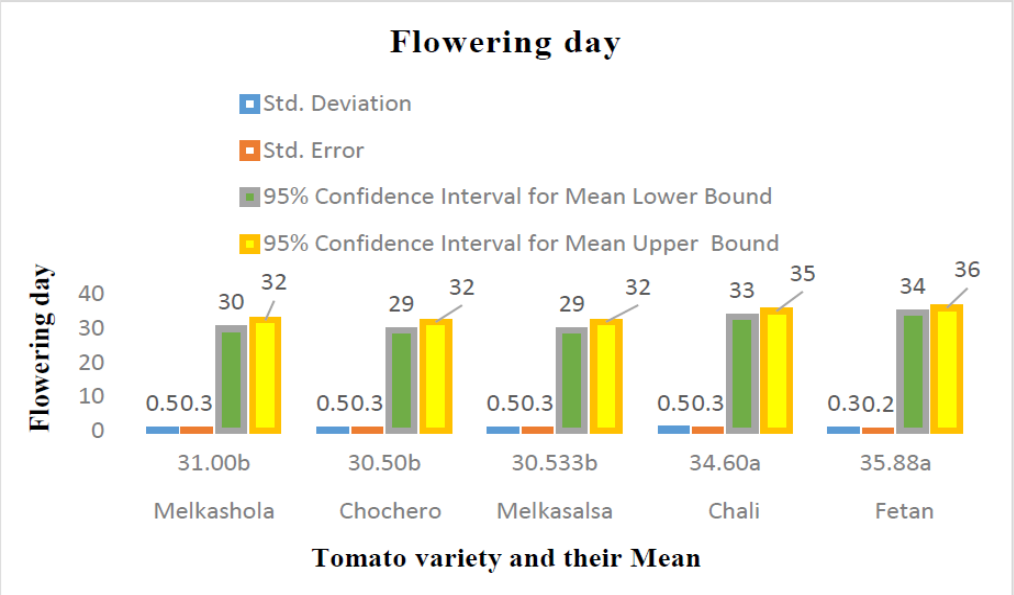

Figure5. *Flowering day of the tomato varieties*

Number of Fruit per Plant

Fruit ripening were observed within 40 days after transplanting and highly significant difference was perceived on average numbers of fruit between the used experimental tomato varieties. The highest significant fruit number were recorded on Chali (30.27) and the lowest fruit number were recorded on chochero with (16.63) conversely it was not significantly different amid the different variety Fetan (28.1) and Melkasalsa (28.07).

The finding is slightly in line with Tsefa B., 2016 with fruit number of newly introduced varieties range (18.16-40.42).Lemma 2000 showed fruit number range between 26-62 and some authors Turhan *et al.*, 2011; Esheteshabul *et al.*,2010; Falak *et al.*,2011;Abrar *et al.*, 2011 stated that the number of fruit per plant shows among 4,46-98.3 and they shows wide different from the current study.

Table 6: *Description No of fruit per plant*

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	406.449	4	101.612	828.361	.000
Within Groups	1.227	10	.123		
Total	407.676	14			

*Means represented by different letter are significantly different at $p \leq 0.05$, **Df**: Degree of freedom, **F:** F value, **LSD**: Least significant difference*

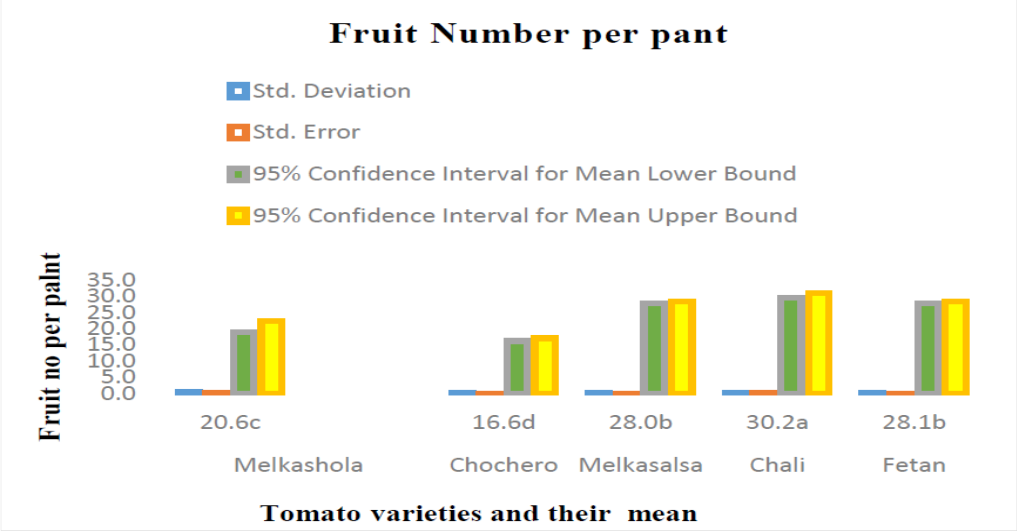

Figure6. *Fruit number of the tomato varieties*

Fruit Girth per Plant

The equatorial (transverse) diameter of the fruit were significant (P≤ 0.05) among the each of varieties ranged from (33.13-65.5 mm). The largest fruit size were showed on Fetan (65.5 mm) or 6.55 cm and the lowest fruit size were recorded on Chochero (33.13 mm) or 3.31 cm. The fruit girth per plant in this study agrees with earlier reports by Syed *et al*. (2001) and Shushay C. and Haile Z,2014 who reported fruit range in fruit width (3.2-5.2 cm) and 27.5 to 64.4 mm. The Several studies (Khokhar *et al.*,2001; Žnidarcic *et al.*,2003; Kacjanmarsic *et al.*,2005; Eshtesha-bul *et al.*,2010; Abrar *et al.*, 2011; Kaushik *et al.*,2011) showed that the width of tomato fruits lay amid 3.20 and 10.67 cm equatorial diameter.

Table7. *Description of Fruit girth*

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	2300.991	4	575.248	4209.129	.000
Within Groups	1.367	10	.137		
Total	2302.357	14			

Means represented by different letter are significantly different at p ≤ 0.05, ***Df****: Degree of freedom,* ***F:****F value,* ***LSD****: Least significant difference*

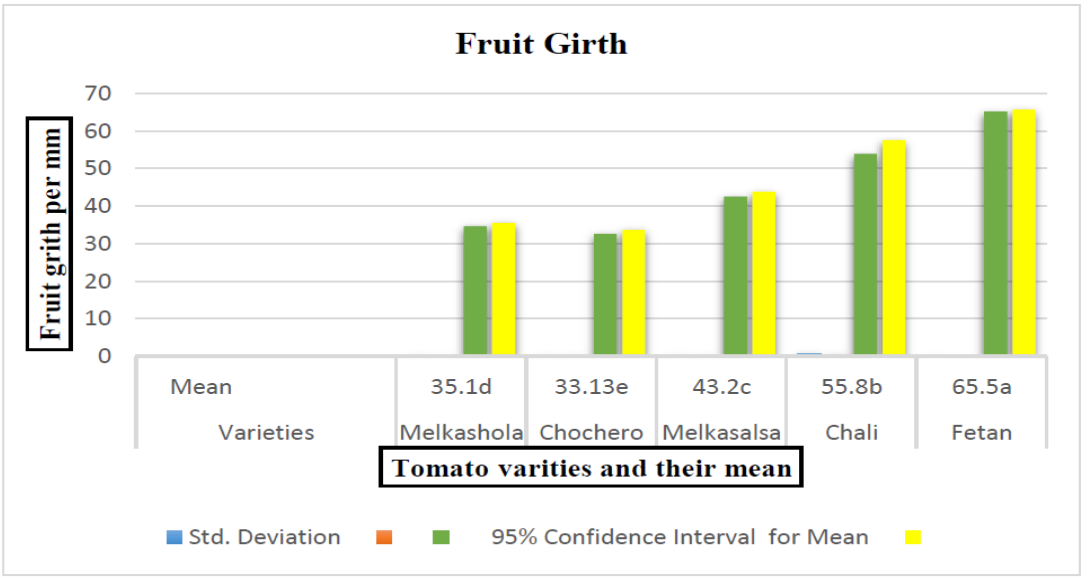

Figure7. *Fruit girth of the tomato varieties per mm*

Total Fruit Yield per 83.3 M2

After transplanting the first harvest were taking place within 53 days and the total yield were expressed by weight of each varieties per 83.3m^2 per three months. Fruit weight per plant showed significant difference (P≤0.05) among the tomato varieties (Table 7).The highest total fruit weight per plant were gained in Melkashola (1688.633 kg) followed by Chali (1531.66 Kg) and the lowest rate were gained from Fetan (1123.4 Kg) on the other hand total fruit weight of varieties Fetan (1123.4 Kg), Chochero (1180.7 kg) and Melkasalsa (1160.8 kg) was not significant different from one another. The current study has wide different with fruit weight showed on with Meseret *et al*., 2012; Ketema *et al.*, 2016 that ranged 14.88--58.00 t/ha and Yuan *et al.*, 2015 has also mentioned that total yield shows with range of 1332-2736 kg/ha and some outcome of the varieties from the study has shown similar finding with the current study.

Table8. *Description total Yield*

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	706100.591	4	176525.148	51.364	.000
Within Groups	34367.527	10	3436.753		
Total	740468.117	14			

Means represented by different letter are significantly different at p ≤ 0.05, ***Df****: Degree of freedom,* ***F:*** *F value,* ***LSD****: Least significant difference*

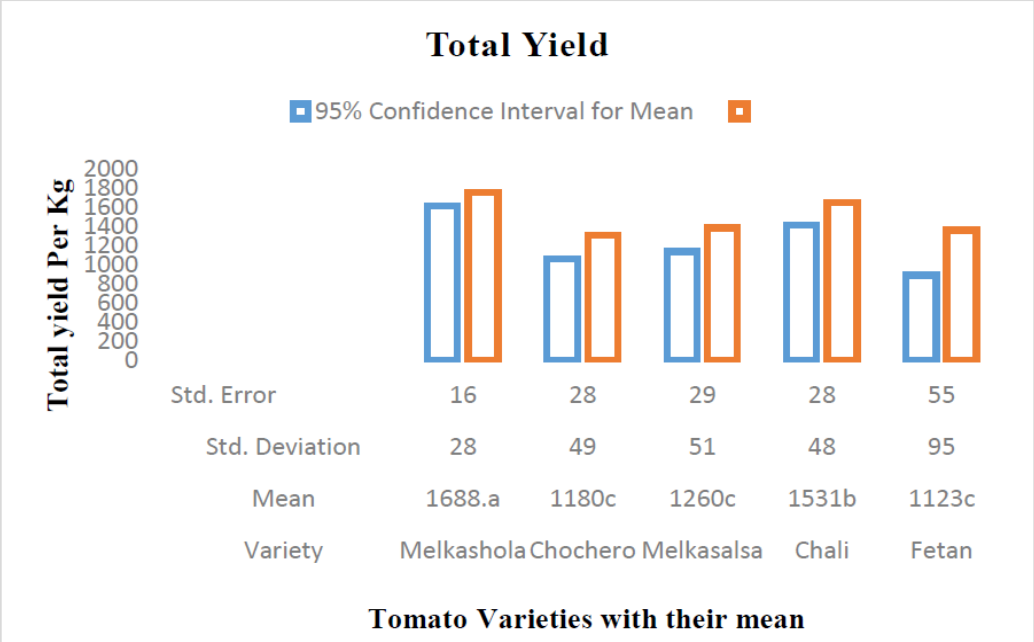

Figure 8: *Total tomato yield of the tomato varieties per Kg*

Table9. *Mean of Germination rate, plant height, Root Height, Flowering day, Fruit No, Fruit girth and Total Fruit Yield during vegetative growth period.*

Variety	Germination rate (%)	Plant Height (cm)	Root Height (cm)	Early Flowering day	Fruit No. per plant	Fruit girth per plant (mm)	Total Fruit Yield per 83m2 (kg)
Melkashola	92.63^a	87.4^a	60.667^a	31.00^b	20.63^c	35.1^d	1688.6^a
Chochero	87.10^b	75.7^d	22.667^b	30.50^b	16.63^d	33.13^e	1180.7^c
Melkasalsa	87.40^b	71.8^e	40.600^b	30.533^b	28.06^b	43.2^c	1260.8^c
Chali	88.03^b	84.9^b	22.000^b	34.60^a	30.26^a	55.8^b	1531.7^b
Fetan	73.33^C	83.5^c	40.66^b	35.88^a	28.1^b	65.5^a	1123.4^c

Means represented by different letter are significantly different at p ≤ 0.05, LSD: Least significant difference

Figure9. *(**A**) Plant height of Melkasalsa, Chochoro, Fetan, Chali and Melkashola respectively from left to right Ascending order (**B**) Root height of Chochero, Chilli, Melka salsa, Fetan, and Melka sholla respectively from left to right in Ascending order (**C**) Fruit of tomato variety Fetan (**D**) Fruit of Melka sholla during harvesting (E) Five the tomato varieties growing on the polycarbonate greenhouse*

CONCLUSION

Generally, tomato is the most important vegetable crops in Ethiopia, providing a higher income to small and big scale farmers compared to other vegetable crops and average yield of tomato in Ethiopia is low on open field. From the outcome of current study, the growth parameters were demonstrations significantly different between the tomato varieties appraised. Consequently, the cultivar Melkasholla was found suitable and loftier as related to other tomato varieties with respect to germination percentage, plant height, root length, early flowering day and total fruit yiel d on the modern Polycarbonate type greenhouse.C hali and Fetan tomato varieties were similarly found superior with respect to number of fruit per plant and Fruit girth per plant on modern Polycarbonate type greenhouse respectively and therefore it is recommended that tomato producers around Ethiopia can use Melkasholla, chali and Fetan tomato varieties for decent quality tomato production in greenhouse.

ACKNOWLEDGEMENTS

Financial support for this study was provided by the Tigray Biotechnology Center PLC (TBC). Authors would like to recognize the technical assistance of the acclimatization team at the Tigray Biotechnology Center PLC and the Author also want to acknowledge Tigray Agricultural Research and Institute (TARI) for providing the Seeds of tomato varieties.

Image 06: *Staking tomato of Melka sholla, Melka salsa,Fetan ,Chilli and Cochero)*

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Citation: *Tsehaye Kidus, Tekestebrhan Areya and Wendwesen Tesfay, "Proportional Enactment of Tomato (Solanum Lycopersicum L. Mill) Varieties under Greenhouse Production Systems of Tigray Biotechnology Center, Ethiopia", International Journal of Research in Agriculture and Forestry, 7(6), 2020, pp. 01-11.*