

Influence of Inter-Intra Row Spacing on Yield Losses of Tomato Cultivars

Wegayehu Assefa¹, Buzuayehu Tesfaye², and Lemma Dessalegn³

¹Melkassas research center, ²Hawassa University,

³Ethiopian Seed Growers and Producer Association

አካላዊ-ጥናት

ቲማቲም ወደ ኢትዮጵያ ከገባ ረጅም ጊዜ ያስቆጠረና በስፋት እየተመረተ ያለ ሰብል ቢሆንም ምርትና ምርታማነቱ ከሌሎች የቲማቲም አምራች አገሮች ጋር ሲነፃፀር እጅግ በጣም ዝቅተኛ ነው። በአሁኑ ጊዜ አርሶ አደሩ በስፋት እየተገበረ ያለው የአመራረት ዘዴ ያለደጋፍ በተለያየ በመስመርና በተከለ መካከል የመትኪያ ርቀት በመጠቀም ሲሆን ይህ ዓይነቱ አሰራር የምርት ብክነት እንደሚያስከትል ቢታወቅም የብክነቱ መጠንና ብክነቱን የሚያስከትሉ ምክንያቶች ተለይተው አልታወቁም። ስለሆነም ይህንን በመረዳት በመልካሳ ግብርና ምርመራ ማዕከል በ2004 እና 2005 ዓ.ም. ያለደጋፍ በተከለና በረድፍ መካከል ያለውን ርቀት በመጠቀም የምርት ብክነት ያስከተሉ ምክንያቶች ተፈትሸዋል። ውጤቱን ለማየት በተከለው መካከል ያለው የተለያዩ ርቀቶች (20, 30 and 40 ሳ.ሜ.)፣ በረድፎች መካከል ያለ ርቀት (70, 80, 90 and 100 ሳ.ሜ.)ና ሁለት የቲማቲም ዝርያዎች ማለትም ለኢንፎርሲዮን ግብፍት የሚውል ቲማቲምን እና የገበታ ዝርያን በማቀናጀት ተምክሯል። ዋና ዋና የምርት ብክነት የሚያስከትሉ ምክንያቶች የተለዩ ሲሆን እነሱም የፍሬ ጫፍ መድረቅ፣ መበስበስ፣ ተባይ፣ በሽታ፣ መሰነጣጠቅ፣ በፀሀይ መቃጠል፣ ቅርፅ ማጣትና ሌሎች ጥቃቅን ምርት አባካኝ ምክንያቶች የተለዩ ሲሆኑ በተጨማሪም ጠቅላላ ምርት፣ ጥቅምና ጥቅም ላይ የማይውል የምርት መጠን በመቶኛ በመውሰድና በማገናዘብ የመተንተን ስራ ተከናውኗል። ጥናቱ እንዳመለከተው በረድፍና በተከለ መካከል ያለው ርቀት እየጠበበ ሲሄድ የፍሬ ጫፍ መድረቅ፣ መበስበስ፣ ተባይ፣ በሽታና ሌሎች ጥቃቅን ምርት አባካኝ ምክንያቶች ከሰተት እየጨመረ የሄደ ሲሆን እንደ ዝርያው ዓይነት ይለያያሉ። ነገር ግን በረድፍና በተከለ መካከል ያለው ርቀት እየሰፋ ሲሄድ በዋናነት ከፍተኛ የሆነ የምርት ብክነት የታየው የፍሬው በፀሀይ መቃጠልና መሰነጣጠቅ ናቸው። ከፍተኛ የሆነ የፍሬ ምርት የተገኘው በጠበበ ተከለው መካከል ባለው ርቀት 20 ሳ.ሜ (100.45 ቶን በሄክታር)ና በረድፍ ርቀት 70 ሳ.ሜ. (92.55 ቶን/ሄክታር) ቢሆንም ከፍተኛ የሆነ ጥቅም ላይ የሚውል የፍሬ ምርት በመቶኛ የተገኘው 90 ሳ.ሜ. (64.8 %) ረድፍ ርቀትና 40 ሳ.ሜ. (56.7%) በተከለው መካከል ባለው ርቀት ሲሆን ነገር ግን ከ30 ሳ.ሜ. ጋር የላቀ ልዩነት አልነበረውም። ቲማቲምን ያለደጋፍ በቦይ የመሰኖ የማምረት ዘዴ ለሚጠቀሙ አምራቾች በዚህ ጥናት በአማካኝ ዝቅተኛ የምርት ብክነት (40%) የተገኘው 30 ሳ.ሜ በ90 ሳ.ሜ ወይም 40 ሳ.ሜ በ90 ሳ.ሜ ለሁለቱም ዝርያዎች ከፍተኛ ጥቅም ላይ የሚውልና ጥራት ያለው ምርት በመልካሳና ተመሳሳይ አካባቢዎች ለማምረት መጠቀም ይቻላል። በቀጣይነት ዝርያዎችን የማሻሻል ስራና የመትኪያ ርቀትን ከሌሎች የአሰራር ዘዴዎች ጋር በማጣመር መፈተሽ ለምርትና ምርታማነትን ለመጨመር አስፈላጊ ነው።

Abstract

Field experiment was carried out at Melkassa Agricultural Research Center in 2012 and 2013 off-seasons using furrow irrigation with the objectives of evaluating the effect of four inter-row spacings (70, 80, 90, and 100 cm) and three intra-row spacing (20, 30 and 40 cm) on yield losses of tomato growing under open field production with fresh market (Bishola) and processing (Cochoro) type of determinate tomato cultivars. The treatments were arranged in 2x4x3 factorial in a split-split plot design in three replications. Data on major yield loss agents such as, blossom end rot, decay, insect, disease, sunburn, crack, catface and others minor disorders were collected; as well as total yield, percent of marketable and unmarketable fruit yield parameters were analyzed. Results of the study showed that inter-intra row spacing and cultivar had a significant ($p < 0.05$) effect on the incidence of blossom end rot, decay,

sunburn, catface, crack, other minor disorders, insect and diseases attacked fruit yield. In most cases for blossom end rot, decay, disease and insect attack and other minor disorders were higher at narrower inter and intra-row spacing combination but it varies with cultivars. Whereas sunburn and cracked fruit were reasonably higher at wider inter-intra row spacing with cultivars. The highest total fruit yield of 100.45 and 92.55 t ha⁻¹ were recorded for narrowest inter and intra-row spacing of 70 and 20 cm, respectively. However, the highest percentage of marketable fruit yield was obtained at 90 cm (64.80%) inter row spacing and 40 cm (56.7%) intra row spacing which have no significant difference with 30 cm. This suggests that on average more than 40% of total yield obtained in this study was unmarketable. Therefore, it will be so necessary to undertake more research on genetic improvement of the cultivars with advanced management options including plant spacing can better transform the present tomato production practices of growers.

Introduction

Like any other crops tomato fruit yield is a complex character that is influenced by many factors (Ara *et al.*, 2007). Lemma (2002) reported that open field production of tomato expose to abiotic and biotic factors that reduce performance of the crop and resulting in lower productivity. Similarly, Fekadu and Dendena, (2006) indicated that in Ethiopia vegetable crops produced under open field using furrow irrigation system and growing under these conditions is not an easy task since the plant exposed many factors, which cause high yield losses.

Inter and intra row spacings influence the production and productivity of tomato. Both too narrow and wide spacings do affect crop yield through competition and shading effect (Heuvelink *et al.* 2009). Spacing is too wide it would result in unnecessary scarifying of yield; however, over-estimating the required density also lead to unnecessary stress on the plants; which in turn has a detrimental effect on yield and yield component (Onwueme and Sinha, 1991). Law-ogbomosho and Egharevba (2009) and Masarirambi *et al.* (2009) as well reported that physiological disorder such as fruit sunburn, cracking and blossom end rot are among the disorders that observed frequently in tomato growing farms due to improper use of plant spacing and other agronomic practices. Burdon (1982) also reported that higher plant densities support fungal and bacterial diseases development of solanaceae. Closed spaced vegetable crops suffer more from disease and insect pest attack due to closed up of canopy which diminish the amount of chemical spray reaching in the lower part of the plant and also create conducive environment for disease and insect pest development (AVRDC, 2003).

Various plant spacings have been practiced by growers in the Central Rift Valley of Ethiopia which is quite different from research recommendation (30 cm x 100 cm). There are also variations between neighbouring growers for the same cultivar; and they use spacing of 70 cm and 100 cm between rows and 20 cm and 40 cm between plants (Wegayehu *et al.*, 2013). To narrow down this gap study was conducted by Geremew *et al.*, (2010) and they recommended 30 cm x 40 cm and inter-intra row spacing, respectively. The authors reported that high total fruit yield was recorded during their studies, and about half of the total yield was unmarketable. However, their study did not investigate causal agents of unmarketability by using different inter and intra-row spacing combinations and did not also incorporated inter-intra row spacings practices of growers.

Therefore, it is necessary to undertake research to indicate the major causal agents of fruit yield losses associated with inter-intra row spacing to come up with options to help growers to increase productivity and marketable fruit yield of tomato. Hence, the objective of this study was to investigate the influence of inter-intra row spacing on yield losses of tomato fruit under open field production conditions.

Materials and Methods

The experiment was conducted at Melkassa Agricultural Research Center, in 2012 and 2013 off season using furrow irrigation. Two tomato cultivars fresh market (Bishola) and processing (Cochoro) were compared in four inter-row spacing (100, 90, 80 and 70 cm) and three intra-row spacing (20 cm, 30 cm and 40 cm). The treatments were arranged in 2x4x3 factorial combination laid out in split-split plot design with three replications where, cultivars were assigned as main plot, inter-row spacing to the sub plots and spacing between plants as sub-sub plot for two years in a plot size of 24 m² (4 m x 6 m) using recommended spacing of 100 cm x 30 cm as a control. The seeds of both cultivars were obtained from vegetable research department of Melkassa Agricultural Research Center. The seedlings were raised in 1m x 5m of seed bed and properly managed as per Melkassa Agricultural Research Center recommendation and healthy and uniform, seedlings were transplanted at 30 days after sowing; at 2-3 leaves stages of growth.

The experimental field was ploughed, harrowed and levelled to facilitate transplanting operation. Trial was fertilized with DAP (18 % N and 46 % P₂O₅) at the rate of 200 kg ha⁻¹ at transplanting as band application and 100 kg ha⁻¹ Urea (46 % N) was side dressed in split application of 50 kg ha⁻¹ 15 days after transplanting and second (50 kg ha⁻¹) at flowering stage at (48 days) of transplanting. Furrow irrigation was practiced every four days in the first three weeks then after at five days intervals. In the experimental field Selecron® 720 EC at a rate of 0.75 lit ha⁻¹; Ridomil® MZ at the rate of 2.5 kg ha⁻¹ were sprayed every fifteen days for controlling insect pests and fungal diseases, respectively; moreover, Cruzeat 2.5 kg ha⁻¹ for controlling bacterial disease were applied two times during the growing period and other cultural practices were applied, when it was necessary.

Data on any agents contributes to yield losses such as insect and diseases attacked, crack, decay, blossom end rot, sunburn, catface, and other minor physiological disorders such as zippering, blush color, blotchy ripening and irregular ripening and under sized (fresh market type) were measured from five randomly selected plants per plot. Encountered fruit diseases were identified at pathology laboratory of Melkassa Agriculture Research Center and some fruits were attacked by more than one disorders classified based on the seriousness of the incidence.

The data were subjected to analysis of variance using SAS analytical software (version 9.2). Combined analyse was made according to (Gomez and Gomez, 1984). When the F-value was significant and a multiple means comparisons were performed using LSD at a P-value of 0.05.

Results and Discussion

Yield: The main effect of inter and intra row spacings exhibited statistically significant differences for total fruit yield, percentage of marketable and unmarketable fruit yield (Figures 1 and 2). The highest (100.45 t ha^{-1}) and lowest (71.41 t ha^{-1}) total fruit yield were obtained at 70 cm and 100 cm inter-row spacing, respectively. Intra row spacing had as well a significant effect on total fruit yield; the highest (92.55 t ha^{-1}) and lowest (74.53 t ha^{-1}) were recorded at 20 cm and 40 cm intra-row spacing, respectively, however; the highest (64.8%) and lowest (32.3%) percentage of marketable fruit yield were recorded at 90 cm and 70 cm inter-row spacing, respectively. Intra row spacing had also a significant effect on percentage of marketable fruit yield. The highest (56.7%) percentage of marketable fruit yield was obtained at 40 cm intra-row spacing and with no significant difference with 30 cm, whereas the lowest percentage of marketable fruit yield (44.3%) at 20 cm intra-row spacing. The highest (66.8%) and lowest (35.5%) percentage of unmarketable yield were recorded at 70 cm and 100 cm inter-row spacing, respectively. Intra row spacing had also a highly significant effect on percentage of unmarketable fruit yield. The highest (55.0%) and lowest (43.3%) percentage of unmarketable fruit yield were obtained at 20 cm and 40 cm inter-row spacing, respectively.

This result in agreement with the findings of Law-ogbomosho and Egharevba (2009) who reported that total tomato fruit yield per hectare increased with increase number of plants per unit area. Similarly, Tesfaye (2012) reported that the highest total tuber yield of potato cultivars was obtained at closer spacing of which higher plant population per unit area. Ara *et al.* (2007) also reported the highest marketable fruit yield of tomato was recorded at wider spacing, but unmarketability increased with decreased of plant spacing which supports the present finding. The authors reported that major factors that caused such high percentage of unmarketable yield were genetic characteristics of cultivars, physiological disorders, decay, disease and insects attack.

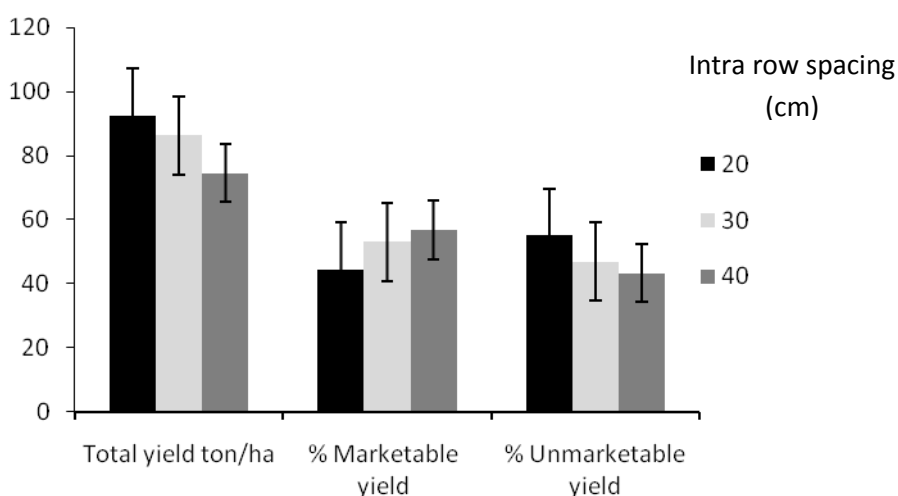


Figure 1: Total yield (t ha^{-1}), % marketable and % unmarketable yields as affected by intra row spacing

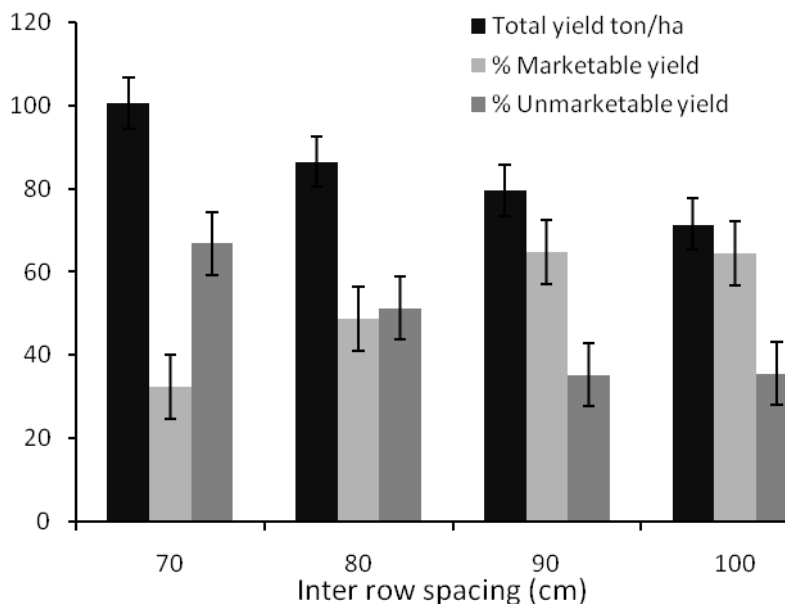


Figure 2: Total yield ($t\ ha^{-1}$), % marketable and % unmarketable fruit yields as affected by inter row spacing

Yield losses due to disorders

Blossom end rot: The interaction effects of cultivar, inter and intra-row spacing on the incidence of blossom end rot was highly significant. Cultivars were responds differently over the same range of spacing (Figure 3). The highest fruit yield losses of $3.66\ t\ ha^{-1}$ was recorded at $20\ cm \times 100\ cm$ from Bishola and there was not significantly different with $30\ cm \times 70\ cm$ while $5.85\ t\ ha^{-1}$ was recorded at $20\ cm \times 70\ cm$ intra-inter row spacing from Cochoro. The lowest fruit yield loss $0.49\ t\ ha^{-1}$ was recorded from Bishola at $40\ cm \times 100\ cm$ whereas $0.41\ t\ ha^{-1}$ at $40\ cm \times 90\ cm$ spacing from Cochoro.

In the study, blossom end rot incidence was increased with decrease in inter- intra row spacing combination and it varied with cultivars due to susceptibility difference. Masarirambi *et al.* (2009) reported that blossom end rot is caused by low level of calcium in the fruit; however, Edossa *et al.* (2013) findings confirmed that the soils of central rift valley of Ethiopia contain adequate exchangeable calcium concentrations. According to Ho and White (2005) blossom end rot is caused by complex inter play of factors. This findings in agreement with the findings of Jovicich *et al.* (2004) who reported that higher plant density increases the occurrence of blossom end rot on bell pepper (*Capsicum annuum* L.) on calcium rich soil. Masarirambi *et al.*, (2009) indicated that at high planting density there is competition between the leaves, which are high-transpiring organs, and the fruits or flowers, which are low-transpiring ones that restricts Ca translocation to the latter; and the problem exacerbated due to Ca translocation to plant organs is through the xylem, whereas through the phloem is negligible. Hence, the amount of calcium moving in to the developing fruit declines, contributing to the onset of blossom end rot. Moreover, according to Kassie *et al.* (2013) most Central Rift Valley of Ethiopia is hot, dry with lower RH climate conditions that enhance transpiration.

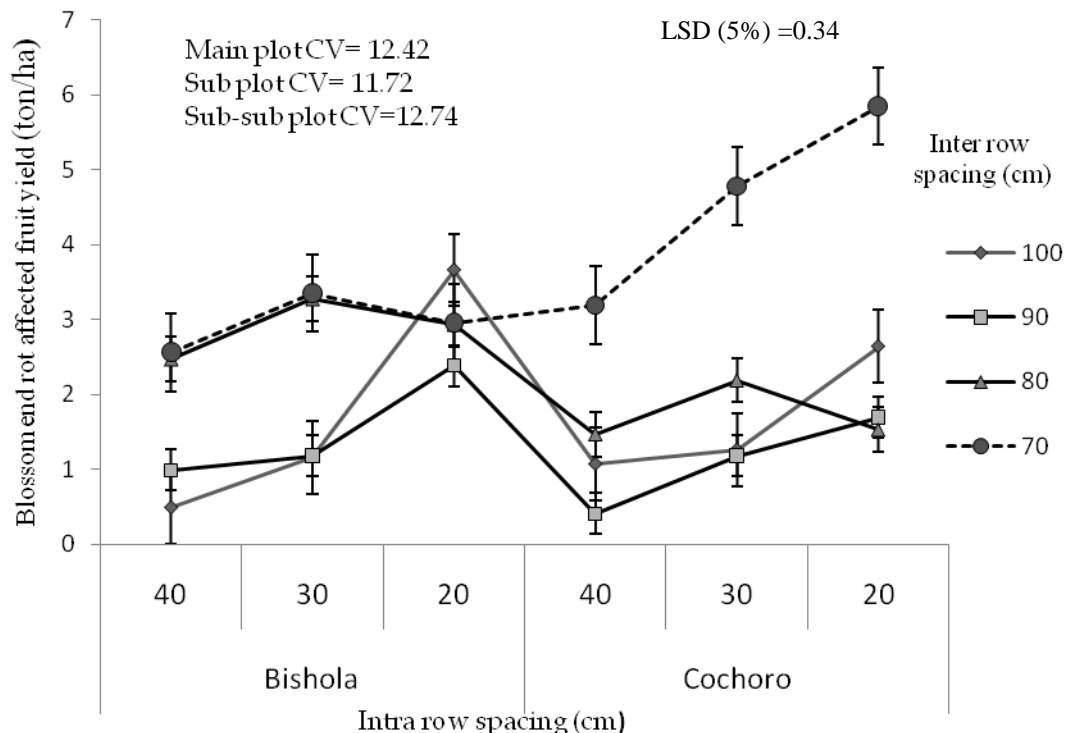


Figure.3. Interaction effect of cultivar, inter and intra-row spacings on incidence of blossom end rot of tomato

Fruit crack: Fruit yield losses due to cracking incidence was significantly affected by interaction effect of cultivar, inter and intra-row spacing (Figure 4). The highest fruit yield losses of Bishola (7.52 t ha^{-1}) was recorded at $40 \text{ cm} \times 100 \text{ cm}$, while for Cochor (0.84 t ha^{-1}) at $30 \text{ cm} \times 90 \text{ cm}$, and this was not significantly different with $40 \text{ cm} \times 100 \text{ cm}$, $30 \text{ cm} \times 100 \text{ cm}$ and $40 \text{ cm} \times 90 \text{ cm}$. Whereas Bishola gave the lowest cracked fruit yield of 2.22 t ha^{-1} at spacing combination of $40 \text{ cm} \times 70 \text{ cm}$ whereas at $40 \text{ cm} \times 70 \text{ cm}$ and $30 \text{ cm} \times 70 \text{ cm}$ fruit cracking was not recorded from Cochoro; reacted differently over the same range of inter-intra row spacing.

In this study several types of fruit cracking were observed radial, bursting, and concentric and cuticle cracking and it were higher at wider inter-intra row spacing. The fresh market cultivar which was more sensitive for fruit cracking than processing type over the same range of spacing due to genetic difference to their anatomical and physiological factors those are attributable to processing type for their thicker pericarp than fresh market type (Masarirambi *et al.*, 2009). According to Peet (1992) fruit cracking varies up on water uptake, humidity, rainfall, temperature and soluble solids (sugars) as well as calcium nutrition and standing water on the fruit have great roles in fruit cracking, along with genetics. Kennelly (2009) reported that these causal factors directly or indirectly affected by plant spacing. This result is also in agreement with the findings of Law-ogbomo and Egharevba (2009) who also reported that high percentage of cracked fruit was recorded at

wider plant spacing than narrow spacing due to less computation effect and rapid movement of water and photo assimilates into the fruits at critical time when the skin of the fruit is losing elasticity and strength. Hence, fruit cracking can be prevented by selecting tomato cultivar tolerant or resistant to cracking and having good canopy architecture that protect fruits from sunlight; maintaining optimum plant spacing and healthy foliage of the plant.

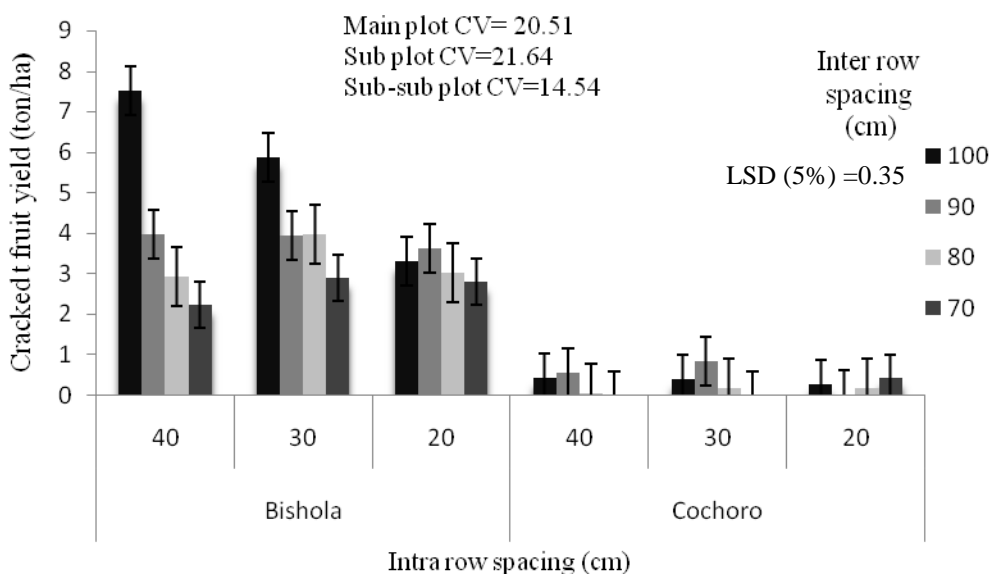


Figure 4. Interaction effects of cultivar, inter and intra-row spacing on incidence of fruit cracking of tomato

Sunburn: The interaction effect of cultivar, inter and intra-row spacing on incidence of sunburnt of tomato fruits was highly significant (Figure 5). The highest fruit yield losses was recorded from Bishola (5.61 t ha^{-1}) at $40 \text{ cm} \times 100 \text{ cm}$ while (6.69 t ha^{-1}) at $40 \text{ cm} \times 90 \text{ cm}$ was for Cochoro. The lowest fruit yield loss from Bishola (2.07 t ha^{-1}) was recorded at $20 \text{ cm} \times 70 \text{ cm}$ whereas (1.64 t ha^{-1}) at $30 \text{ cm} \times 70 \text{ cm}$ spacing was obtained from Cochoro (Figure 5). However, susceptibility of the cultivars varies with the same range of inter-intra row spacing combinations.

As wider inter-intra row spacing Cochoro was more susceptible to sunburn than Bishola due to canopy arrangement relatively shaded up and protected its fruits against direct sunlight during fruit growth and maturity. However, susceptibility of both cultivars increased with increase in intra-inter-row spacing. Similarly, Law-Ogbomosho and Egharevba (2009) reported that the highest amounts of sun-burn fruits were recorded at wider spacings as the fruits are not fully protected by foliage. The opposite was true for high plant densities as most of the fruits were protected against direct sunlight. Hence, this disorder should be reduced through manipulating of proper spacing and select cultivars with good architecture to shades the fruit during growth (Peet, 2009).

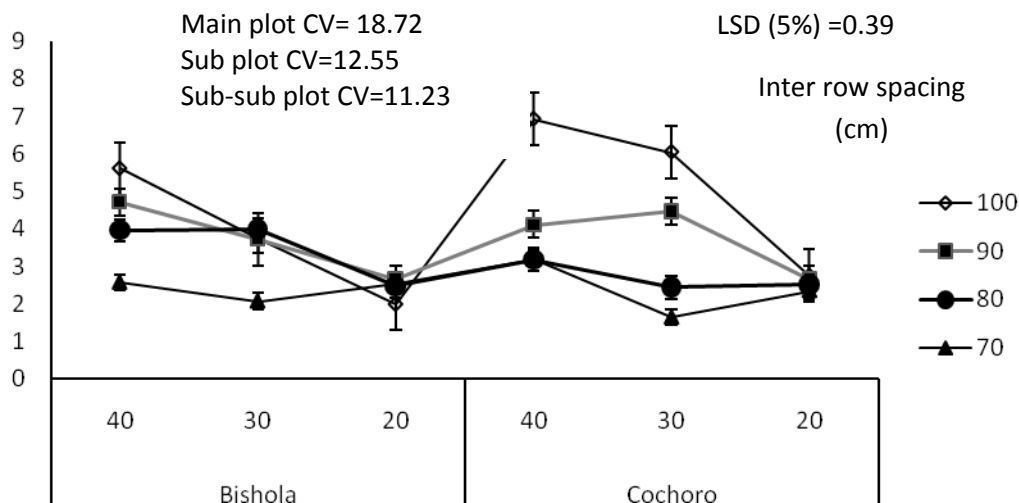


Figure. 5. Interaction effects of cultivar, inter and intra-row spacing on incidence of sunburn tomato fruit yield

Diseased fruit: The interaction effects of cultivar and inter-row spacing had significantly affected for diseases attacked tomato fruit. The highest and lowest fruit yield losses recorded for Bishola (4.01 t ha⁻¹ and 1.51 t ha⁻¹) whereas for Cochoro (6.11 t ha⁻¹ and 1.05 ton ha⁻¹) at 70 cm and 100 cm inter-row spacing, respectively (Figure. 6). Increasing inter-row spacing from 70 cm to 100 cm the amount of attacked fruit of Bishola decreased by 62.09% whereas for Cochoro decreased by 82%. In this study bacterial speck and blight were identified as the most important diseases. Cultivar Cochoro was more susceptible to the diseases than Bishola over the same range of inter-row spacing. Burdon (1982) reported that high plant density created favourable conditions for diseases development and it was strong positive correlations between plant density and disease intensity.

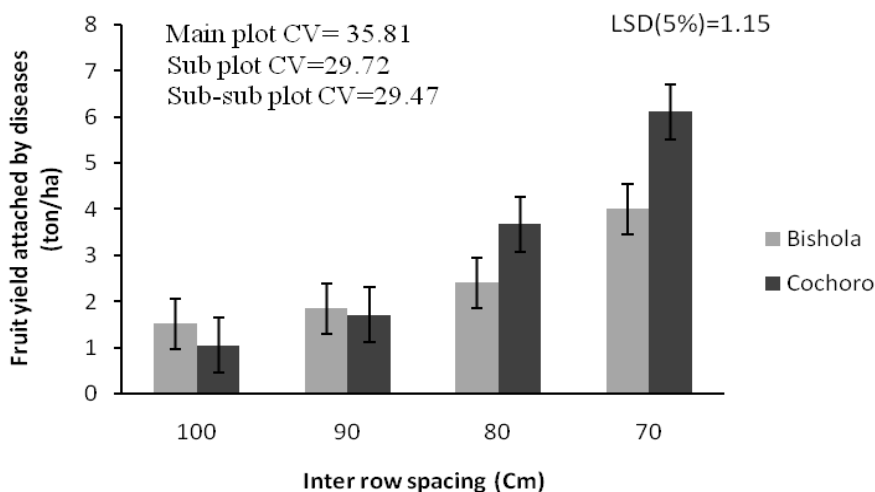


Figure. 6. Interaction effects of cultivar and inter-row spacing on the incidence of disease attacked fruit

Insect attacked fruits: The highest fruit yield losses of cultivar Bishola (9.42 t ha^{-1}) was recorded at $40 \text{ cm} \times 70 \text{ cm}$, and there was not significantly different at $20 \text{ cm} \times 70 \text{ cm}$, $40 \text{ cm} \times 70 \text{ cm}$ and $20 \text{ cm} \times 80 \text{ cm}$ spacing, while for Cochoro (18.24 t ha^{-1}) at $20 \text{ cm} \times 70 \text{ cm}$. Whereas the lowest fruit yield loss of both cultivars Bishola (1.7 t ha^{-1}) and Cochoro (1.48 t ha^{-1}) was recorded at spacing of $40 \text{ cm} \times 90 \text{ cm}$ and not significantly different from $40 \text{ cm} \times 100$ and $30 \text{ cm} \times 100 \text{ cm}$. Decreasing inter-intra row spacing combination for both cultivars the amount of fruits yield affected by insect pest increased though cultivar Cochoro more liable than Bishola.

The major insect pests identified during the study were African bollworm and potato tuber moths (PTM) as well as mite damage. The interaction effect of cultivar, inter and intra-row spacing on fruit yield loss by insect pest attack was highly significant (Figure-7). In most case fresh market tomato fruits highly affected due to juicy and soft skin nature without difficulty highly preferred by insect pests than processing type (Bsheer and Baseet, 2011); however, contradictory result were observed in this study. This could be due to plant structure of processing tomato which created advantageous environment for insect pest attack than fresh market. Closely spaced vegetables and horticultural crops suffer more from insect pests, which encouraged the feeding activity of the insect pests (AVRDC 2003). Because of it was provided environmental condition conducive for insect pests and consequently a favourable and productive shelter for the insect pests and thus makes it easier for the pest to find its food near on the host plant.

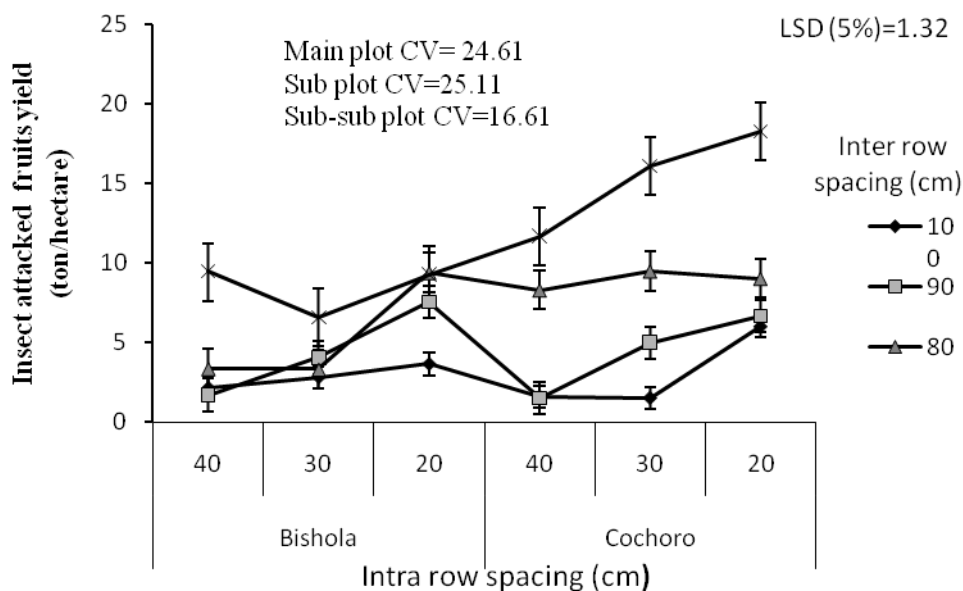


Figure. 7. Interaction effects of cultivar, inter-intra row spacing on incidence of insect attacked tomato fruits yield

Fruit decay: Decreasing inter-intra row spacing combination significantly increased the losses of fruit yield due to the incidence of decay; nevertheless it differed in relation to cultivars. The highest fruit yield loss by incidence of decay of Bishola (26.58 ton ha⁻¹) was recorded at 30 cm x 70 cm, and was not significant different with 20 cm x 70 cm and 40 cm x 70 cm while for Cochoro (24.48 ton ha⁻¹) at 20 cm x 70 cm. The lowest fruit yield losses by incidence of decay of both cultivars were recorded at wider inter-intra row spacing (40 cm x 100 cm).

The cause of fruit decay was when normal fruits came in contact with irrigation water or moist soil. As result causes the fruits start to perish or exposed to infections. In most cases when inter-intra-row spacing became narrower fruited plant may not get enough space specially when there was no stacking and the fruit directly exposed to moist soil or water resulted in high amount of fruit decay. Cultivar Bishola had more vulnerable to fruit decay than Cochoro over the same range of inter intra row spacing due to short plant height the branches are close to the soil surface that given high **chance of** contact with moist soil or irrigation water. The problem was exacerbated specially when inter row spacing became narrower. Vegetable crops produced under open field using furrow irrigation systems that are exposed to many biotic and abiotic factors, which causes high yield losses (Fekadu and Dendena, 2006). Hence, in this production system the use of appropriate spacing with other integrated management options are very crucial to reduce the incidence of the problems.

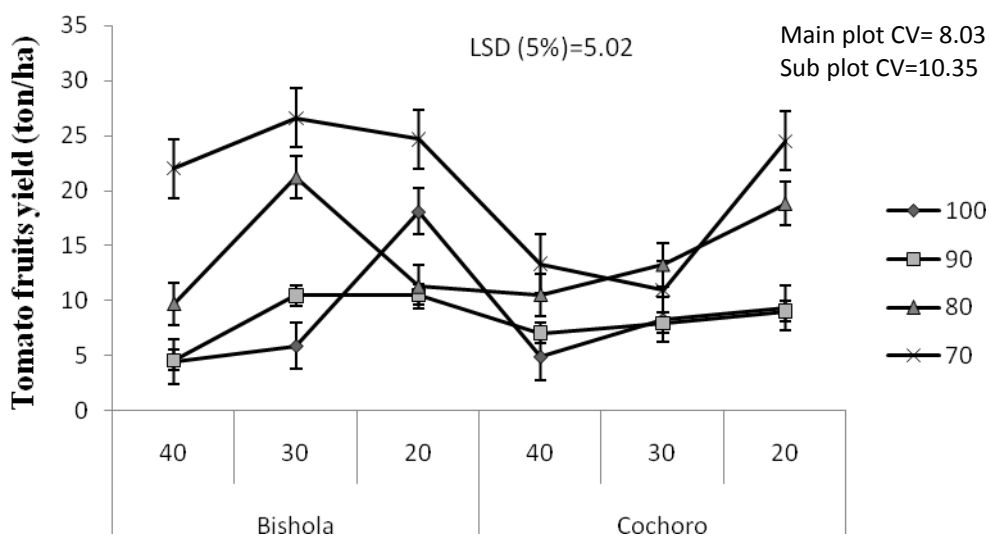


Figure 8. Interaction effects of cultivar and inter -row spacing on incidence of decayed on tomato fruits yield

Minor disorders: Fruits disorders that caused significant marketable fruit yield reductions were zippering, blotchy ripening, irregular ripening and others. The interaction effect of cultivar, inter and intra-row spacing for fruit yield losses due to these agents were highly significant (Figure. 9). Fruit yield losses of Bishola and Cochoro increased with decreasing

in intra and inter-row spacing combination, though it varied in with cultivars due to genetic variation. The highest fruit yield losses of Bishola (26.58 t ha⁻¹) was recorded at 30 cm x 70 cm while for Cochoro (24.48 t ha⁻¹) at 20 cm x 70 cm, and the lowest yield losses for both cultivars Bishola (4.45 ton ha⁻¹) and for Cochoro (4.48 ton ha⁻¹) were recorded at 40 cm x 100 cm spacing.

Blotchy ripening, irregular ripening and others were caused due to low soil nutrition of nitrogen and potassium, low temperature, low light intensity, shading effect, and soil moisture fluctuation and also differ with cultivar (Masarirambi et al., 2009). According to Kennelly (2009) plant spacing could also contributed to its occurrence due to unnecessary stress on the plants due to computation, which in turn has a detrimental effect on fruit yield and it also varies from varieties to varieties. The others such as zippering are probably a genetic defect that only develops under certain environmental conditions. These disorders may be controlled by avoiding conditions previously described as causal factors and develop varieties tolerant or resistance to disorders.

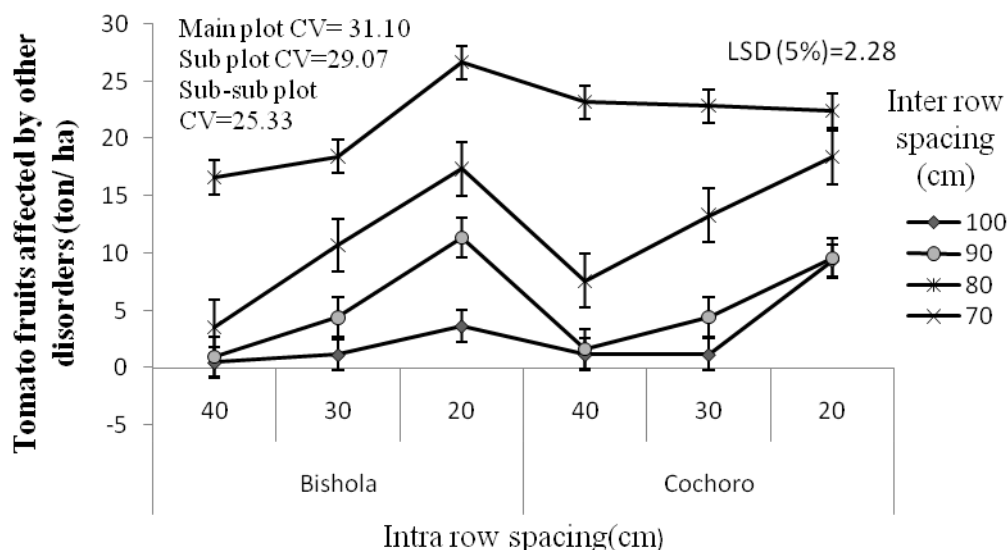


Figure 9. Interaction effects of cultivar and inter -row spacing on incidence of others tomato fruits yield

Catface: Fruit yield loss due to incidence of catface was significantly affected by interaction effects of inter-intra-row spacing and the highest (0.9 t ha⁻¹) and the lowest (0.4 t ha⁻¹) fruit yield loss were recorded at intra-inter-row spacing combination of 20 cm x 90 cm and 40 cm x 100 cm, respectively (Figure 9). According to Masarirambi *et al.*, (2009) indicated that catface is caused by something that occurs during the formation of the flower that results in the fruit not developing normally. However, there is lack of published information on the exact cause of this disorder association with plant spacing. It was observed in first harvest fruit yield of both cultivars. To alleviate the problem varieties should be selected that historically have had little problem with catfacing.

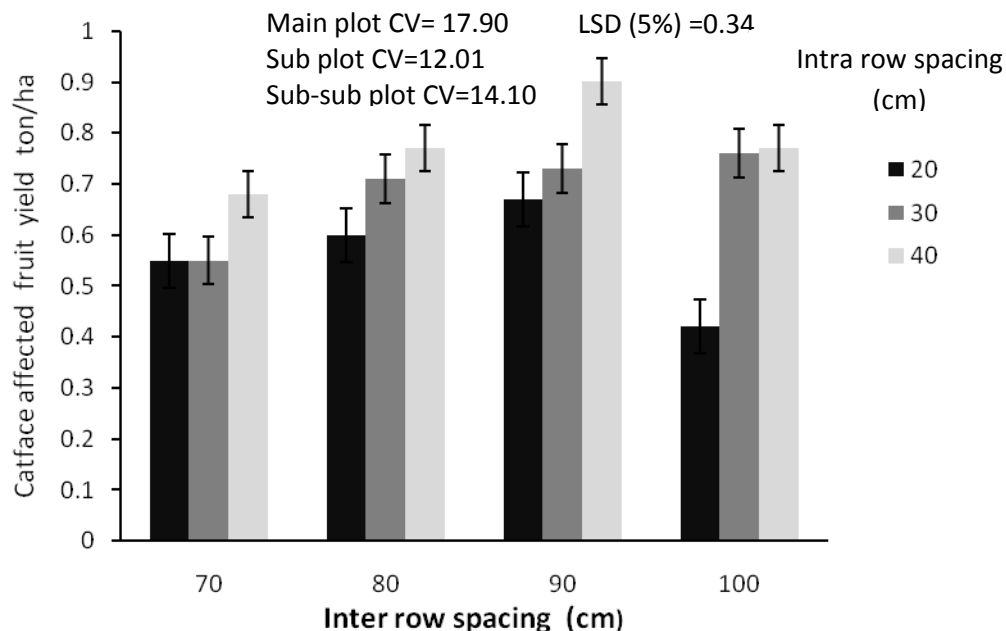


Figure: 10. Interaction effects of cultivar, inter and intra-row spacing on incidence of catface affected tomato

Conclusion

High yields combined with high fruit quality are common requirement of tomato growers as well as end users and this can only be achieved if critical production factors are taken into consideration. Though minimizing these losses significantly increased yields, quality and then higher profits. To obtain high marketable yield and quality fruit further study need to undertaken on genetic improvement of the cultivars and through developing advanced management options that improve the present low productivity of tomato of growers through manipulating plant spacing vs staking, drip irrigation, plant nutrition on macro and micro element, planting technique, diseases and insect pest management options associated plant spacing. As well as the present old method of furrow irrigation practice associated with inconsistent plant spacing has been contributed a lot for the occurrence of most these disorders. Thus, the present practices it should be progressed to better scheme.

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