Open Field Performance of Tomato (Lycopersicon esculentum Mill.) Cultivars in the Rainy Season at Woreta, South Gondar, Ethiopia

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Abstract. Tomato production in Amhara region of Ethiopia has been restricted to dry season cultivation using irrigation while open field tomato production under rain fed was considered difficult mainly due to disease incidence. Despite ever increasing year round demand for tomato fruits, supply is nearly nil in the rainy season and prices skyrocket. Aiming to evaluate the performance of tomato cultivars with the application of appropriate field management practices including fungicide spraying, field experiments were conducted at Fogera Agricultural Research Center during the rainy season of 2014. Cultivars Melka salsa and Melka shola consistently performed superior than the other cultivars ultimately producing the highest marketable tomato fruits, on average 230.53 and 222.73 quintal per hectare, respectively. The study further revealed that cultivar Melka salsa was the earliest in attaining fifty per cent flowering and the most tolerant in its reaction to diseases. Unmarketable fruit number due to diseases, insects and physiological disorder ranged from 20.3 to 72.9 per cent. Developing and applying appropriate integrated pest management technologies are thus required to further reduce unmarketable fruits, although it is unequivocally crucial to improve cultivars for better productivity too. Open field tomato production under rain fed is thus highly profitable with the use of integrated pest management practices.

Keywords: Cultivar, disease, open field, rainy season, unmarketable fruit

1. INTRODUCTION

Tomatoes are the most widely cultivated and lucrative vegetables in Amhara region in particular and in Ethiopia in general. With the expansion of irrigated farming, market oriented tomato production has been expanding in the last few years, enabling various actor including growers, merchants, consumers, middlemen, transporters, to take part and benefit in the value chain of this important horticultural venture.

Ethiopia was renowned for its agriculture or food production dependent on rain fall. Wherever there was shortage or unreliable rainfall, the country was therefore relying on food aid. Frequent dry spells and droughts exacerbate the incidence of crop failure and hence food insecurity and poverty (Awulachew et al., 2007). Encouraging agricultural strategies and commitment from the government have now resulted in extensive production using irrigation contributing towards tackling recurring drought and avoiding food dependency on rainfall alone. To improve the productivity of land and labor and increase volumes of production, Ethiopia is increasingly investing in promoting water development technologies, especially, at both small and large-scales irrigation. Converting available water resources in their surroundings to food production in the dry season has now become the tradition of small scale farmers. This expansion of irrigation has led to shifting subsistence production system towards targeting to maximize return per unit area, which further encouraged farmers to emphasize on high value vegetables such as tomatoes.

Tomatoes in general have been however restricted to dry season production using irrigation. Open field rain fed tomato production was considered difficult solely due to disease severity leading to complete destruction of tomato pants. Fentahun et al. (2009) underlined that tomatoes are not grown in the rainy season because of disease problems. According to Pandey et al. (2006) tomato production during rainy season in open field condition is very difficult and the production during the season is very low in Nepal. Duncan et al. (2012) noted that rainy season brings a combination of high temperatures and humidity that favors development and spread of diseases and voracious insects in south west Asia. They further showed that desirable vegetables, such as lettuce and tomatoes, are difficult to produce under rainy season conditions without significant inputs such as plastic
row covers and pesticides. Tomato cultivation is generally more restricted by diseases than pests inmost locations in Nigeria (Arogundade et al., 2007). Given the right weather conditions and an early initial infection, the most devastating disease of tomatoes during the rainy period include early and late blights and septoria leaf spot. Despite the importance of tomatoes in the daily diet of the people of Amhara region in Ethiopia and ever increasing demand for this crop, fresh tomato supply during the rainy period is therefore almost nil and the price climbs up. On the other hand, fresh tomato supply is high in the dry season. Fentahun et al. (2009) also showed that tomato production peaks towards the mid dry season causing a market glut and falling prices. Tomato production in Nigeria is done during the dry season (Ayoola, 2014) while its production is scarce during the rainy season because of high disease incidence associated with growing tomatoes. Pathogens attack on crops resulting in distressing monetary loss for farmers and shortage of food in developing nations (Alam et al., 2014).

Critical shortage periods for fresh tomatoes around Woreta are from June to October. Merchants in the nearby big cities like Bahir Dar tried to transport tomatoes from Addis Abeba and sell with high price - 20 Ethiopian Birr per kilogram at Bahir Dar. Consumers in small cities like Woreta do not; however afford such a high price - 20 Birr per kilogram of fresh tomatoes. Consequently, fresh tomatoes are not available in the market from June through October. On the other hand, tomato production in the dry season using irrigation is a traditional practice in various areas in the region. The price of fresh tomatoes during the dry period is thus low- going down to two to three Birr per kilogram.

Unless tomatoes are cultivated in a warm, dry, sunny area by applying water only underneath the plants, not on the leaves or fruit, infection is inevitable if inoculums for initial infection are available in the surrounding. Tomato production is thus difficult in an open field under rain fed condition, when the weather is humid, cloudy and moist. Utilization of improved field and disease management practices along with tolerant cultivars can however help to produce tomatoes under rain fed. Since tomato is very expensive during rainy season, farmers could fetch good price (Pandey et al., 2006).

Some tomato cultivars may have tolerance or resistance to those major diseases. Other strategies to control those diseases include frequent application of preventive and therapeutic fungicides. This is sometimes difficult due to the emergence of new resistant strain of, for instance, late blight. The objective of this study is therefore to evaluate the performance of tomato cultivars under rain fed production practices and try to minimize or control diseases with the use of appropriate multiple strategies including cultural practices and fungicide applications.

Greenwald (2013) underlined the importance of multiple strategies to limit development and spread of diseases in an open field rainfed tomato production. These may include growing resistant plant cultivars, conduct regular disease scouting, monitoring the weather for disease favorable environmental conditions, remove nearby weeds and discard live weed plant material in the Nightshade family, use preventive fungicide applications, immediately remove diseased plant material at first sign (burn or burry), and discard harvested fruit from infected plants. The use of furrow or drip irrigation or soaker hoses can lessen the amount of water splashing on plant foliage and limit the spread of the inoculums.

2. MATERIAL AND METHODS

2.1. Description of the location

Field experiments were conducted at Fogera Agricultural Research Center during the rainy season of 2014. The Center is located at the south periphery of Woreta town (Figure 1) of Fogera district of South Gondar Administrative zone in Amhara Region, Ethiopia. Woreta lies at 11° 58′ N latitude and 37° 41′ E longitude. It has an altitude of 1819 m above sea level and receives average annual rainfall of 1230 mm. Mean minimum and maximum temperature of the area is 12 and 28°C, respectively. The soil is red clay (vertisol) rich in underground water.

2.2. Seedling and transplanting

Seeds of five improved cultivars were obtained from Melkassa agricultural research center of the Ethiopian Institute of Agricultural Research. Seedlings were raised in an open field under rain fed. Seedlings of each cultivar were raised on 2m x 1m (adjacent plots) thoroughly prepared beds, 5 cm raised from the surface. Seeds were drilled on rows with ten cm inter-row spacing and it was covered lightly with fine soil and mulched with dried grass until emergence. Weeding was accomplished as deemed necessary. Seedlings were thinned at first true leaf stage to allow 2-3 cm distance within plants (intra-row spacing). Seedlings generally attained transplantable size in four weeks. Healthy, vigorous and uniform seedlings of pencil size were transplanted in the field.

Seed sowing and seedling transplanting dates for the first experiment were the 13th of June and the 9th of July, 2014, respectively. Seeds for the second experiment were sown on the sixth of August, 2014.
and transplanting was accomplished on the fifth of September 2014.

2.3. Treatments and design

Open field experiments were carried out from June to October, 2014 and from August 2014 to January 2015 to evaluate the performance of cultivars under rain fed production conditions. The treatments consisted of five cultivars, viz. Melka salsa, Melka shola, Miya, Fetan and Bishola laid in randomized complete block with three replications. For each cultivar a 5 m by 3 m plot with 30 cm and 100 cm intra- and inter-row, respectively, spacing was used, accommodating 30 plants in five rows for each treatment. Gangways in between replications and plots were, in that order, 1.5 m and 1m wide. Experimental plot was thoroughly plowed and leveled. Ridges were then prepared on sides of which transplanting was done.

<table>
<thead>
<tr>
<th>Table 1: Plot cover, disease score and days taken to 50 per cent flowering</th>
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<tbody>
<tr>
<td>Tomatoes</td>
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<tr>
<td>Melka shola</td>
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<td>Plot cover</td>
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<td>Days to 50% flowering</td>
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<td>Disease score a month after transplanting</td>
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<td>Disease score at fruiting</td>
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Means followed with the same letter within a raw are not significantly different at P < 0.05.

<table>
<thead>
<tr>
<th>Table 2: Marketable yield of tomato cultivars in quintal per hectare</th>
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<tr>
<td>Period of transplanting</td>
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<td>------------------------</td>
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<tr>
<td>July</td>
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<tr>
<td>201.44&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>September</td>
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<td>Combined result</td>
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<table>
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<tr>
<th>Table 3: Percent unmarketable fruit number</th>
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<tr>
<td>Period of transplanting</td>
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<tr>
<td>------------------------</td>
</tr>
<tr>
<td>July</td>
</tr>
<tr>
<td>49.33&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>September</td>
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<td>Combined result</td>
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Means followed with the same letter within a raw are not significantly different at P < 0.05.

Replanting to replace dead or weak seedlings in field establishment were done a week from transplanting. Inorganic fertilizers in the form of Diamonium phosphate (DAP) (18:46:0) and urea (46:0:0) were applied at the rate of 150 and 100 kg/ha (kilogram per hectare), respectively. DAP was applied at transplanting while urea is applied in two splits, the first at transplanting and the second 11/2 months from transplanting. Standard field management practices such as weeding and cultivation was performed uniformly during the growing seasons for all cultivars; no supplemental irrigation water was however applied to either of the two trials.

A total of six fungicide sprays against diseases were made from the 24<sup>th</sup> July up to the 9<sup>th</sup> September 2014. Depending on the weather condition and disease incidence, the interval for spraying varied from six to ten days. Spraying has been some times repeated within 2-4 days interval when it was by coincidence followed by a heavy rain. Fungicides used include Agrolaxyl (3 kg/ha), Ridomil Gold Mz 68 WG (3kg/ha) and Mancozeb (unizeb 80% wp) (2kg/ha). First and second spray was made with Agrolaxyl while Mancozeb was used in the third and fourth spray. Ridomil was applied for fifth and sixth sprays. Spraying was done after thoroughly mixing fungicides in 500-700 liters water per hectare.
2.4. Data collection

Seedling emergence, vigor and field establishment after transplanting were recorded. Field establishment is noted by counting seedlings that successfully resumed growth after transplanting. Vigor is recorded referring to stiffness of seedlings in a plot, one was recorded for plots with the most weakest seedling while five refers to plots with very strong seedlings.

Data was collected on disease incidence, plot cover, 50 per cent flowering and maturity. Visual judgment is made to record the proportion of the plot surface covered by tomato foliage. Number of days required from transplanting date to the day on which 50% of the plants in a plot flowered was recorded. Fruit yield was harvested at appropriate maturity time (when fruit color turns to yellow and red) and categorized as marketable and unmarketable fruits.

Marketable fruits are those with average size and above, and are free from visible damages due to diseases, insects and physiological disorder. Marketable fruits were counted and weighed whereas unmarketable fruits were counted and sorted out based on their respective causes, i.e., diseases, insects, physiological disorder or undersized fruits. Data was subjected to analysis of variance using SAS software and least significance difference (LSD) was used to compare treatment means when there was statistically significant difference (P<0.05).

3. RESULT AND DISCUSSIONS

Cultivars Melka salsa and Melka shola had the most vigorous seedlings during transplanting, whereas cultivars Fetan and Miya had the weakest seedlings. Field establishment and growth was generally good except some replacement of dead seedlings was
needed a week after transplanting. Although the difference in plot cover among cultivars is not significant, cultivars Melka shola and Melka salsa were however superior in field establishment and plot cover (Table 1).

![Figure 2: Average marketable fruit number per hectare (in thousands) for the two transplanting periods of July and September](image)

![Figure 3: Marketable fresh tomato yield (kg/15m² plot) over harvesting periods from tomatoes transplanted in July](image)
Fig. 4: Marketable fresh tomato yield (kg/15m² plot) over harvesting periods from tomatoes transplanted in September

Fig. 5: Photo of diseases and insect attack observed during the experimental period

Cultivar Melka salsa was the earliest in attaining 50% flowering within 47.67 days from transplanting while Melka Shola and Bishola took 52.67 and 54.3 days, respectively (Table 1). Menberu et al. (2012) have also shown variations among cultivars and intra-row spacing in achieving 50 per cent flowering. In
spite of regular fungicide spraying by closely monitoring tomato plants in the field, infection and development of symptoms of diseases were observed almost on all cultivars considered in this study. Cultivar Melka salsa, however demonstrated significantly negligible infection and disease development (Table 1). Spraying fungicides namely, Agrolaxyl and Ridomil at six to ten days interval were found effective in mitigating disease development at Woreta. According to Shamiyeh et al. (2001), frequent fungicide applications, usually on a seven day schedule, are imperative for acceptable disease control and successful tomato production.

Field management practices such as planting on sides of ridges could have further helped for the performance of tomatoes by draining excess water. Staking (support using stick and/or rope) to tomato plants is also desirable to avoid lodging and fruit contact with moist soil that may otherwise cause fruit rotting. Open field tomato production under rain fed is thus possible with close follow up at least two to three times daily. Plants that appear healthy this morning or evening would otherwise be completely lost the other morning or evening. Arogundade et al. (2007) also stressed the importance to scout for disease symptoms and to rogue infected plants as soon as they are detected. Not only monitoring for plant disease symptoms is crucial, but also analysis of every hour weather conditions should be seriously considered to learn to recognize the weather conditions that foster the spread of diseases. Cloudy or rainy weather conditions for several hours will favor development and spread of infection with explosive disease development leading to complete destruction of plants unless strategies are followed to mitigate disease progresses. Whenever weather conditions are favorable for disease development, preventative fungicides need to be sprayed or else curative fungicides should be applied whenever symptoms are observed on a single leaf of a single plant.

Six harvestings at a week interval were made from tomatoes transplanted in July and the peak was from the third harvest (Figure 3). In the third harvest, cultivar Melka salsa gave 10.18 kg marketable fruit, whereas cultivars Miya, Melka shola, Fetan and Bishola produced 7.45, 6.53, 6.00 and 3.85 kg, respectively. On the other hand, seven harvestings were made from tomatoes transplanted in September (Figure 4). Overall average marketable yield of cultivar Melka shola is the highest, 283.79 qt/ha (quintal per hectare), for tomatoes transplanted in September while cultivar Melka salsa gave the highest yield (201.44 qt/ha) for tomatoes transplanted in July (Table 2). Experiments of the rainy season of 2014 revealed that cultivars Melka salsa and Melka shola consistently performed superior than the other cultivars showing that these two cultivars are suitable for open field tomato production under rain fed. For tomatoes transplanted in July, fresh tomato loss ranged from 40% for cultivar Meka salsa to 72.9% for cultivar Bishola (Table 3). The main causes for these unmarketable fruits are fruit rot due to blight and blossom end rot (Figure 5). On the other hand, unmarketable fruit number for tomatoes transplanted in September ranged from 20.3% for cultivar Melka shola and Melka salsa to 45% for cultivar Bishola (Table 3). Major problems observed were fruit borer (Figure 5) and sun scald. According to Gajanana et al. (2006), tomato fruit borer, Helicoverpa armigera (L) is the most important insect pest in Karnataka state, India and further showed that, in spite of regular spraying of insecticides, its incidence in farmers’ field varied from 10 to 20 per cent and at times, this pest causes yield loss up to 40 per cent.

In both experiments, cultivar Bishola and Fetan exhibited the highest fruit loss. According to Panday et al. (2005) losses may go up to 60% due to bacterial blights and 80-86% due to early blight. In the tropics, tomato production is severely constrained by diseases and insect pests (Sirinvasan, 2010). It was further underlined that fruit borer, early blight, late blight and fusarium wilt are among the major insects and diseases. Emphasis to develop and apply appropriate integrated pest management technologies is thus required to further reduce the loss incurred by diseases and insects, although it is unequivocally crucial to improve cultivars for better productivity too.

Except for cultivar Miya, marketable tomato fruit number was generally higher for tomatoes transplanted in September than for those transplanted in July (Figure 2). Ayoola (2014) showed that tomato crop in Nigeria is more economically efficient under irrigation than rain fed productions system. The price of a kilogram of fresh tomatoes at Woreta is 20 Ethiopian Birr and above during the rainy period where as the price goes down to two to three Birr per kg during the dry season. Profitable open field tomato production is therefore possible during the rainy season provided that disease tolerant/resistant cultivars are used with every day weather analysis and scouting to control development and spread of diseases using multiple strategies.

4. CONCLUSION

The study revealed distinct variability among cultivars in tolerating disease attack and ultimately producing marketable fruit yield. Melka salsa and Melka shola were the highest yielding cultivars suitable for open field rain fed tomato production at Woreta. Unmarketable fruit number due to diseases, insects and physiological disorder ranged from 20.3 to 72.9
percent. Reducing this significant yield loss through the use of multiple disease and insect controlling strategies such as cultural, mechanical, biological and chemical methods could further improve profitability of open field tomato production in the rainy season. The use of disease resistant/tolerant cultivars is a priority agenda, although other components of integrated pest management practices including fungicide application are critical for rain fed tomato production in the open field. Fungicides such as Agrolaxyl and Ridomil were found effective in mitigating disease development at Woreta. Relentless research effort is therefore needed first and for most to develop disease resistant and/or tolerant cultivars with high productivity during the rainy season. Secondly developing other components of integrated pest management to improve yield and quality, and to reduce fruit loss due to diseases, insects and physiological disorder is required.

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