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Full Length Research Paper

Evaluation of tomato (*Lycopersicon esculentum* L.) variety tolerance to foliar diseases at Kenya Agricultural Research Institute Centre-Kitale in North west Kenya

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Most vegetable cultivar evaluation trials focus on yield and quality attributes. However, disease tolerance is not routinely evaluated along with other parameters. The objective of this study was to evaluate new tomato cultivar for yield, quality and tolerance to foliar diseases. The most ubiquitous and devastating pathogen that infects tomatoes in the North rift Kenya is *Phytophthora infestans* that causes late blight and *Alternaria solani* that causes early blight. There are several disease management practices that can be implemented to manage this disease including rotation, mulching, spacing, fungicide applications, and use of tolerant varieties. This study aimed at testing different varieties. Six new tomato cultivars, TKA143-33, TKA158-6, TKA193-28, TKA155-18, TKA193-2, TKA195-43 alongside a local check, CALJ were evaluated. The trial was laid out in completely randomized Block design (RCBD) layout replicated four times. The results showed that there were significant differences among varieties during the long season but not short rain season on yield. The local check CAL-J gave the least yield. There was low incidence of foliar diseases on the newly introduced varieties. This suggests that some of the new varieties could be good candidates for long and short season production seasons.

Key words: Tomato, variety, on-station trial, disease tolerance, evaluation Kenya.

INTRODUCTION

Kenya has a strong horticultural industry spanning over several years of experience in the production of fruits, vegetables and cut flowers for the domestic and export markets (Export Promotion Council, 2004). During the last two decades, horticulture has emerged as a major export industry, and together with tourism and tea are the top three foreign exchange earners for Kenya (GoK, 2004). Horticulture occupies 14% of the horticultural surface cultivated and contributes to 23% of the value of the sector's production. However, the sub-sector is faced by a number of challenges both biotic and abiotic factors (FAO, 2005; GoK, 2010). For example among the horticultural fruit crops, tomato faces a number problems including diseases and pests (abiotic) (Maerere et al., 2006).

The biotic factors include temperature and humidity fluctuations in long and short seasons are favorable conditions for pathogens to develop, lowering tomato yield in the season. Furthermore, these factors promote the development of a variety of diseases. Tomato production is among the important horticultural crops. Tomato (*Solanum lycopersicum* L. [syn. *Lycopersicon esculentum* Mill.]) belongs to a large family of plants called the Solanaceae, which contains many important food crops, including potatoes and aubergine (egg plant) (Purseglove, 1984). Tomato (*L. esculentum* L.) is one of the most widely grown vegetable food crops not only in Kenya but the other parts of East Africa and the whole world at large, second only to potato (FAO, 2005; Maerere et al., 2006). The crop is among the key crops in the horticultural industry in the country. It is one of the

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Table 1. Tomato crop production in three selected districts of North Rift region.

Crop	Acreage/yield in tons by years									
	2005		2004		2003		2002		2001	
	Ha	Yield /Ha	Ha	Yield/Ha	Ha	Yield /Ha	Ha	Yield /Ha	Ha	Yield /Ha
Trans Nzoia district										
Tomatoes	165	25	162	18	160	18	155	18.5	150	18.5
Cabbages	300	20	280	18	310	18	305	16	290	18
Kales	350	20	300	18	325	18	325	16	320	18
Carrots	28	10	26	8	27	6	20	4	25	4
West Pokot district										
Cabbages	78	0.9	67	0.7	90	1.0	105	1.0	135	1.6
Kales	90	0.9	92	0.8	130	1.3	90	0.9	125	1.5
Tomatoes	10	17	17	27	16	25	22	28	23	22
Local vegetables	14	98	20	126	23	167.9	8.3	58.93	3.2	21.12
Nandi district										
Kales	143	3.5	174	3.5	172	4,.2	894	24	380	9.5
Cabbage	114	2.3	150	3.0	304	7.6	685	18	400	10,
Tomato	48	48	50	50	81	81	411	8.5	150	3.7
Onions	23	230	-	-	16	240	148	645	63	1.5

leading processed vegetable crops in the country. Despite the fact that Kenyan tomatoes satisfy the interior demand and have a strong export demand there is seasonal scarcities. In addition, traditionally the tomato fruits have been marketed fresh picked from the field and is the best selling fresh market vegetable crop (AVRDC, 2006; Ban, 2006; Boriss and Brunke, 2005). Processing tomatoes are grown throughout the region and in a number of soil types and temperature regimes ranging from Upper Humid zones to lower midland zones (AVRDC, 2006; Jaetzold et al., 2005). Tomato is a vegetable crop of considerable economic importance in Kenya and specifically in the North Rift region. The fruit is relatively nutritious and contains moderate quantities of vitamin C (Vallareal, 1980). The crop is an important economic activity in the region as it is one key enterprise to the farming community in North rift, in terms of food and income generation. All over the North Rift region and the country at large, small-scale growers are increasingly becoming commercial producers of tomatoes, cabbages, onion and many other horticultural crops through the adoption of more efficient technologies (DAO, 1999-2005).

In the North Rift Kenya the area occupied by tomatoes in each year is about 300 ha with an average yield of about 1.0 to 2.0 tons per ha (Table 1) (DAO, 1999-2005). However, the potential yield is between 15 and 17 tons per ha and about 30 tons per ha. The yield gap is attributed to a number of yield reducing factors which include both biotic and abiotic. Apart from insect pests (*Heliothis armigera*, *Bemisia tabaci*, *Thrip palmi*), there are diseases which significantly contribute to the yield gap. Fungal diseases, one of the biotic factors, (especially early blight, late blight and Fusarium wilt), bacterial diseases (bacterial wilt, bacterial spot, etc.) and virus diseases (for example leaf curl, spotted wilt, etc.) are a serious problem in Kenya and other tomato growing countries. A number of technologies exist and if adopted would improve yields. One of the key technological components in tomato production package that has contributed to increased yield is the development of varieties. Improved new varieties which 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. There are many varieties and types of tomatoes based on uses (processing and fresh market types) and growth habits (determinate and indeterminate types). There are basically two types of tomato: 1) Determinate types that produce flowers at almost every internode until terminal flowers are formed. Plant growth stops at this point. Determinate tomatoes usually have a quite bushy appearance and are hence, often referred to as 'bushy' tomatoes. 2) Indeterminate types continue growing almost indefinitely and need staking and pruning .They produce flowers at every third internode. The varieties that are grown in Kenya include money maker (indeterminate) and cal J (determinate). Although several high yielding varieties and hybrids have been developed during the last decades, there is potential need for them to be tested under various agro-climatic conditions. Most vegetable cultivar trials focus on yield and quality attributes. However, disease tolerance is not routinely

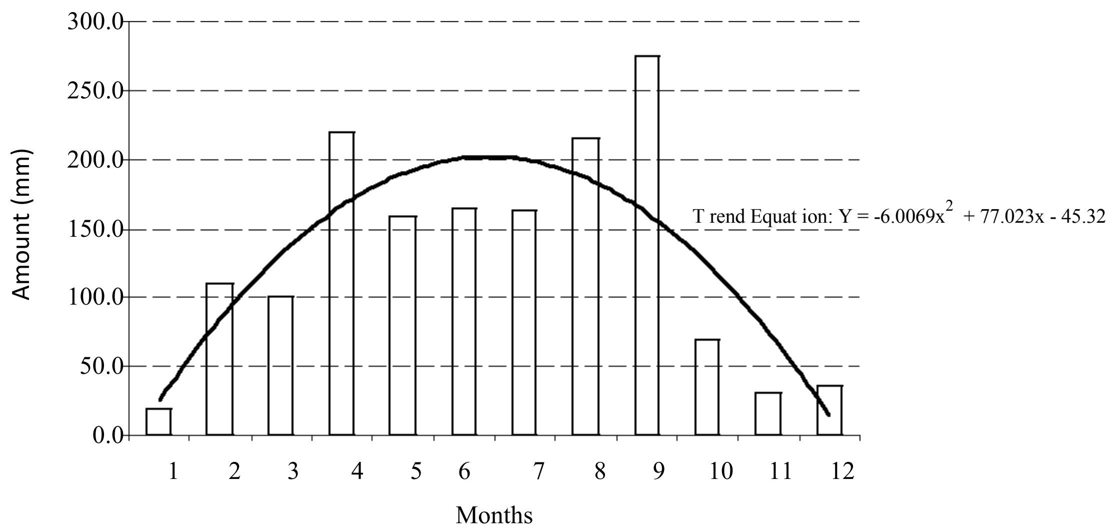

Figure 1. Typical annual rainfall distribution for Seasons 1 and 2 at Kenya Agricultural Research Institute Centre (KARI), Kitale.

evaluated with other criteria. The objective of this research was to evaluate new and established tomato cultivars for yield, quality and tolerance to foliar pathogens. The most ubiquitous and devastating pathogen that infects tomatoes is early blight (*Alternaria solani*). There are several cultural practices that can be implemented to manage this disease including rotation, mulching, spacing, fungicide applications, and tolerant cultivars.

Further, tomato late and early blight disease which are caused by the fungi *Phytophthora infestans (*Mont.) and *A. solani* respectively have been identified as the main constraint in its production (Tumwine et al., 2002; Waiganjo et al., 2006). The present study was undertaken to evaluate the performance of some *P. infestans* and *A. solani* tolerant genotypes for yield and its components along with some local check varieties to find out the desirable ones for North Rift Kenya. Most of the varieties grown are vulnerable to a number of diseases and pests. Of the diseases, the most important one is the late and early blight. The tomato late blight disease is caused by *P. infestans* while *A. solani* the fungus causing early blight disease, which are difficult diseases to manage (Jett, 2002) and cause significant reduction in yield. These diseases which are caused by seed borne fungi, influences the overall health germination and final crop stand (Bissdorf, 2005; Pandey et al., 2006). One of the options to manage the disease is the use of tolerant/resistant varieties and hybrids. Successful production of tomato depends on the choice of varieties for a particular location (Chaerani, 2006). The purpose of this study was to evaluate different tomato varieties for disease tolerance and yield superiority. It was hypothesized that the new varieties are superior to the local check, Cal-J tomato variety.

Trends in vegetable production in selected district of selected regions of Northwest Kenya

Tomatoes, kale and cabbages are the most commonly consumed vegetables in the three districts and are grown in most parts of the districts. Other vegetables in the district include spinach, carrots, broccoli and cucumber among others. Weather conditions dictate available amounts of vegetable produce in the market and prices rise and fall respectively (DAO, 1999-2005). Tomato demand is high throughout the year, hence providing ready market. However, continuous production on the same plot reduces the yields due to increase in disease and pest incidences. Farmers are keen on tomato production considering that, the crop does not require so much rainfall. However, in the last few years, increase in both fungal and viral infections on tomatoes, has reduced production of the same. Shortage of land hinders balanced rotation that could reduce disease occurrence in tomatoes. Production of the vegetables dominates the riverbeds and former forestlands.

METHODOLOGY

Site characteristics

This was an on-station trial conducted at Kenya Agricultural Research Institute (KARI), Kitale which is situated on latitude 1° 01' north, longitude 35°7.5' east, and altitude 1890 m above sea level. The centre lies in upper midland (UM) zone, that has an altitude ranging from 1700 to 2000 m above sea level. The annual mean day temperature ranges from 17.9 to 19.4°C. The rainfall is bi-modally distributed with an average annual rainfall of 1050 to 1100 mm per year with a bimodal pattern. The rainfall pattern for the year 2007 when the trail was held is shown in Figure 1. The soil types are loamy with a pH ranging from 5 to 6, which are suitable for

Table 2. Yield per ha. of tomato varieties grown KARI Kitale 2006- Long rains (LR) and short rains (SR).

Season	Variety name	Mean (kg/ha)*	SE	95% confidence interval for mean		Minimum (kg/ha)	Maximum (kg/ha)
				Lower bound	Upper bound		
Long rains	TKA-143-33	7666.67[bc]	462.59	5676.30	9657.04	6777.78	8333.33
	TKA-158-6	8740.74[ab]	498.28	6596.81	10884.67	7777.78	9444.44
	TKA-193-28	8111.11[ab]	169.72	7380.85	8841.37	7888.89	8444.44
	TKA-155-18	9000.00[ab]	256.60	7895.95	10104.05	8555.56	9444.44
	TKA-193-2	8000.00[abc]	769.80	4687.82	11312.18	6666.67	9333.33
	TKA195-43	8666.67[ab]	513.20	6458.54	10874.80	7777.78	9555.56
	CALJ-Control	7000.00[c]	390.21	5321.07	8678.94	6555.56	7777.78
Short rains	TKA-143-33	20000.00[a]	3093.20	6691.03	33308.97	16111.11	26111.11
	TKA-158-6	21888.89 [a]	631.80	19170.46	24607.32	20666.67	22777.78
	TKA-193-28	21481.48 [a]	514.53	19267.63	23695.34	20555.56	22333.33
	TKA-155-18	23074.07 [a]	2149.11	13827.22	32320.93	19777.78	27111.11
	TKA-193-2	21111.11 [a]	714.34	18037.54	24184.68	19777.78	22222.22
	TKA195-43	20555.55 [a]	1059.93	15995.04	25116.07	18777.78	22444.44
	CALJ-control	19814.81 [a]	934.77	15792.81	23836.81	18000.00	21111.11

*Means with different letters (grouping) differ significantly according to Fishers protected LSD (P<0.05).

tomato growing.

Experimental design

Six newly introduced tomato varieties and one commercial tomato variety were planted in April (long rains) and October (short rains) 2007. The trial was laid out in a randomized complete block design with four replicates. Each replicate contained seven varieties: TKA143-33, TKA158-6, TKA193-28, TKA155-18, TKA193-2, TKA195-43 and CALJ-control. Each plot had four rows and plants spaced at 75 x 50 cm. The seeds were raised in the nursery and transplanted after 4 weeks Transplanting was done when the seedling were 12 to 15 cm tall. Di-ammonium phosphate was used as basal fertilizer at transplanting at the rate of 200 kg per ha and calcium ammonium nitrate. (CAN) was used as top-dress four weeks later at the rate of 150 kg per hectare. The experimental plots were given optimal agronomics management practices. Harvesting tomatoes at fully ripe stage, that is, when fruit green turns to normal varietals colour. Harvest commenced on June 25th, 2007 and continued through September 30th till October 30th for long rains while harvesting period for short rains was January to march. Yield data was recorded for each harvest using electric balance scale.

Visual disease ratings (incidence and severity leaves, petioles and stems) were made in mid September by visually examining each plot from the non-sprayed block and assigning each cultivar a descending number based on the severity of early blight (EB) infection. Disease incidence can be defined as the proportion of plants (leaves, etc.) diseased, or the number diseased out of N plants (leaves, etc.) observed while disease severity is the relative or absolute area of plant tissue affected by disease (sometimes called "intensity). For many fungal (and other) plant diseases, severity is the area of plant surface with lesions, often it is represented as a proportion (percentage). The full list of diseases considered in the rating were, Alternaria Stem Canker (ASC), Bacterial speck/wilt (BSP), Early blight (EB), Fusarium Crown Rot (FCR), Fusarium Wilt (FW), Late Blight (LT), Root Knot Nematode (NE), Stemphylium (grey leaf spot) (St =); Verticillium Wilt (VW); and Tomato Spotted Wilt Virus (TSWV). Using developed field data field notebooks, data was collected and recorded on the incidences of late blight and early blight, yield and storability qualities of the tomato plant. The disease scoring (qualitative data) was done on scale rating of 0 to 3 where 0 and 1 = resistant (no symptoms on plants < 20% necrosis on leaves), 2 = moderate (20 to 45 necrosis on leaves) and 3 = vulnerable (severe symptoms with (>45% necrosis). The quantitative data on yield was analyzed using analysis of variance, using the general linear model procedure (GLM) of the SAS program version 8. Data was analyzed using a two-way analysis of variance. Treatment means were separated using Fishers Least Significant Difference (LSD) at p< 0.05 (Steel and Torrie, 1980).

RESULTS

Yield levels

There must be a minimum yield difference between two varieties before one can statistically conclude that, one variety actually performs better than the other. This is known as the LSD. When the difference in yield is less than the LSD value, one cannot conclude that, there is any real difference between two varieties. As shown in Table 2, there were significant differences (p<0.05) in yields among the varieties in the long rains. This could be attributed to excessive rain that created conducive environment for the development of the pathogen causing late blight disease which results in yield reduction and therefore differences in disease ratings is more pronounced than in short rains. The results also showed that, there were no significant differences among tomato varieties in the short rains. However, the yields were relatively high in the short rains compared to long

Table 3. Blight disease tolerance rating of selected tomato varieties.

Season	Variety name	Disease tolerance rating	Storability
	TKA-143-33	Tolerant	Fair
	TKA-158-6	Tolerant	Good
	TKA-193-28	Resistant	Fair
Long rains	TKA-155-18	Resistant	Fair
	TKA-193-2	Resistant	Fair
	TKA195-43	Tolerant	Good
	CALJ-control	Susceptible	Good
	TKA-143-33	Tolerant	Fair
	TKA-158-6	Tolerant	Good
	TKA-193-28	Resistant	Fair
Short rains	TKA-155-18	Resistant	Fair
	TKA-193-2	Resistant	Fair
	TKA195-43	Tolerant	Good
	CALJ-control	Susceptible	Good

Disease rating scale: 0 to 9, 1 = No tolerance to early blight, extreme early blight infection, 9 = excellent early blight tolerance, (0 to 1 resistant; 2 to 6 = moderate, 7 to 9 vulnerable).

rains.

Disease rating

Disease rating was done during trial implementation and the results are as shown in Table 3. All the varieties were resistant to *P. infestans* and *A. solani* except Cal-J the local check. This implies that the new lines have the potential for résistance to the blight diseases.

DISCUSSION

It has been shown that farmers choose tomato variety to grow depending on a number of factors among which include production potential, market demand, regional adaptability, disease resistance and the end use of the product (Orzolek et al., 2006). One of the key constraints in adapting tomato varieties are crop pests and diseases which may require integrated pest and disease management options (Raini et al., 2005). For example, in some parts of Kenya including the north rift region, money maker tomato variety is highly preferred in the market by many farmers because of the size and taste while other varieties like Cal-j may are preferred in central Kenya because they can be sold to processors for drying, and tomato paste processing due as they have high total soluble solids (TSS) requirement. Successful tomato production in northwest Kenya is to get enough production for local market demand to be used for salad and as part of a recipe for cooking. However, the processing type tomatoes can often be resistant or tolerant to disease. Annually, *A. solani* Sof. causes 15 to 40% loss of yield and quality to the fresh market tomato production in the north rift region and the whole country at large where vegetable are grown. To identify the most promising sources of resistance for the disease, a collection of tomato cultivar samples was studied under natural infection with the disease agent. In this we evaluate six different tomato varieties (TKA-143-33, TKA-158-6, TKA-193-28, TKA-155-18, TKA-193-2, TKA195-43, and CALJ-Control) for disease tolerance and yield superiority for northwest Kenya farming systems. The results of this study indicated that, long rain tomato production there were significant differences among the tomato varieties on yields during long rains. There were no significant differences of yield during short rains. This may imply that, probably due to rainfall during the long season which sets in mid march through August to September, creating a conducive micro-climate for the development of foliar diseases. This result confirms the work done by Pandey et al., 2006 who carried out an experiment in open field condition and plastic houses. The short season started in October and slowly reduced till December (Figure 1). The diseases particularly blight, are more widespread during the wet and humid conditions than during dry conditions therefore growing of this varieties could be more challenging as in terms of disease. The long rains in the region also coincide with tomato scarcity because of low yields due to disease and pest pressure.

In most cases in short rains season during which condition favours tomato, farmers in the North rift region produce surplus of tomato, that induces low to very low market price of tomato. In some situations, some farmers fail to harvest tomato fruits since their labor is more costly than what they can get from selling harvested tomato. By contrast, tomato in long rain season fetches very high market price. Thus, in this season, if farmers can manage even 40 to 70% of tomato plants to harvesting stage, they would get more benefit than that from tomato grown in short rain season even with 100% of plants alive. However, long rain season tomato production is often at risk of disease infection that discourages farmers to grow. Thus, regionally produced tomato often never meets market demand in this season. As a result, the region imports tomato from other regions including across the border in this period.

CONCLUSIONS AND RECOMMENDATIONS

Although, there are no varieties with complete resistance to major tomato diseases in Northwest Kenya and other similar environments, the results study indicated that some varieties may have partial tolerance. The tested varieties showed some tolerant/resistant to *P. infestans* and *A. solani* except Cal-J the local check. Suggesting that the new tomato varieties could be good candidates for Kenyan farming systems production seasons. In addition, some tomato varieties tested were significantly superior to the local checks in yield during the long rains. This implies that, considering the introduction of these varieties in the Kenyan farming systems would be relevant in disease management and safe farming from using pesticides but increases the yields. The results showed that, there were significant differences during the long rains in yield of different varieties with the control yielding the lowest. However there is need for further research to evaluate other indeterminate tomato varieties.

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