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Response of late blight disease resistant-variety to common occurring tomato diseases in the field

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ABSTRACT

A study to determine field performance of tomato late blight disease resistant-variety was conducted during long rain seasons of the years 2011/2012 and 2012/2013 at the Crop Museum of Sokoine University of Agriculture, Morogoro, Tanzania. Treatments were laid out in a complete randomized block design with three replications. Three tomato varieties: Cal J, Meru and Tanya were planted. Significant differences in diseases incidence and severity were observed among tomato varieties whereby Cal J and Tanya were susceptible to tomato late blight and Septoria leaf spot while tomato variety Meru was resistant to the former two diseases. However, Meru was highly susceptible to tomato early blight disease than Cal J and Tanya. Results revealed that, the tested varieties were equally susceptible to Fusarium wilt and tomato yellow leaf curl diseases. The study suggests that less susceptible tomato variety Meru could be used to manage tomato late blight disease but susceptible to other diseases, therefore, a call to breed for multiple disease resistant varieties.

Key words: tomato varieties, early blight, late blight, Septoria leaf spot, Fusarium wilt, tomato yellow leaf curl

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INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) is a vegetable crop which belongs to the Kingdom Plantae, Phylum Angiosperms, Class Dicotyledonae, Order: Solanales, Family: Solanaceae. The plant is an annual herb; with erect to prostrate stems up to 2-4 m long. It has a strong taproot of 0.5 m deep or more, with a dense system of lateral and adventitious roots [13, 30]. Additionally, the stem is solid, coarsely hairy and glandular [13, 30]. Botanically, tomato was classified for the first time in 1753 whereby it was placed in the genus *Solanum* by Linnaeus as *Solanum lycopersicum* L. (derivation, 'lyco', wolf, plus 'persicum', peach, i.e., "wolf-peach"). However, in 1768, Philip Miller placed it in its own genus, and he named it *Lycopersicon esculentum* Mill. This name came into wide use, but was in breach of the plant naming rules. Technically, the combination of *Lycopersicon lycopersicum* (L.) H. Karst. would be correct, but this name (published in 1881) has hardly ever been used. Therefore, it was decided to conserve the well-known *Lycopersicon esculentum* Mill., making this the correct name for the tomato when it is placed in the genus *Lycopersicon* [12]. Two of the major reasons some still consider the genera separate are the leaf structure (tomato leaves are markedly different from any other *Solanum*), and the biochemistry whereby many of the alkaloids common to other *Solanum* species are conspicuously absent in the tomato [1]. The crop has its origin in the South American Andes (Ecuador, Peru and Chile). It was spread to Europe then, to Southern and Eastern Asia in the 17^{th} century and subsequently to the United States, Africa and the Middle East [13, 30]. In Tanzania, tomato is the most important vegetable crop representing 51% of total fruits and vegetables production. Its production is widespread in the country with a total annual production of more than 145 000 tons [20].

Tomato (*Solanum lycopersicum* L.) production in Tanzania is depending on pesticides usage as a major means to manage pests. Currently, the use of pesticides in tomato management is increasing due to occurrences of many known and new invasive pests. Disease resistance is one of the proposed means to manage diseases in crop production [3, 11, 32]. Tomato yields as low as 2.2 t/ha has been reported to be associated with both biotic and abiotic factors [19]. Tomato late blight disease (*Phythophthora infestans* (Mont.) de Bary) alone contributes to 46% yield loss in Tanzania [2, 19]. Other common tomato diseases occurring in Tanzania are such as early blight (*Alternaria solani* Sorauer), synonym to *Alternaria tomatophila* [29], Septoria leaf spot (*Septoria lycopersici*), Fusarium wilt (*Fusarium oxysporum* f. sp. *lycopersici*), Cladosporium leaf mold (*Mycovellosiella fulva* (Cooke) Arx), powdery mildew (*Leveillula taurica*), verticilium wilt (*Verticillium* spp.), bacterial spot (*Xanthomonas vesicatoria*), bacterial canker (*Corynebacterium* spp.), bacterial speck (*Pseudomons syringae* pv. *tomato*), bacterial wilt (*Ralstonia solanacearum*), tomato yellow leaf curl (*Tomato Yellow Leaf Curl Virus*), tomato spotted wilt (*Tomato Spotted Wilt Virus*), cucumber mosaic (*Cucumber Mosaic Virus*) and root knot nematodes.

Previous studies which listed diseases to be the major tomato production constraints in Tanzania [19] do not provide quantitative values of disease incidence and severity in the fields. Estimated yield losses from tomato diseases are based on the visual estimate of individual disease while in the field the combination of more than one disease is commonly observed. The information gathered when all diseases are assessed is vital to detect differences in disease susceptibility between crop varieties as a whole. Farmer might prefer a resistant variety against a certain disease but on the other hand is very susceptible to another one. Therefore, the reaction of all diseases occurring in the field should be assessed to assist in determining economic losses due to diseases or to suggest diseases management options.

Several efforts have been made by researchers to come up with tomato varieties with reasonable resistance to late blight disease in Tanzania. Previously, two tomato varieties, “Meru” and “Kiboko”, were developed and released in 2007 and 2008, respectively [24] by the AVRDC. Both varieties have resistance to late blight, a common disease that can significantly reduce tomato yields. The two varieties produce good yields of quality tomatoes under climatic conditions (cool, wet weather) that favour development of late blight, when susceptible tomato varieties fail. On the contrary, these varieties are highly susceptible to tomato early blight disease [25] as a result they have low potential of being grown in hot humid areas as well as during the off-season. Other new tomato varieties, “Duluti” and “Tengeru 2010” were released in February 2011. These varieties have resistance to early and late blight diseases thus; they have the potential to bridge the seasonality gap in tomato production by allowing farmers to grow tomato during the off-season [23]. The objective of this study was to assess performance of tomato late blight resistant variety to other commonly occurring diseases under field conditions.

MATERIALS AND METHODS

***Establishment of tomato crop and experimental design*:** Seedlings of three tomato varieties (Cal J, Tanya and Meru) were raised in 4 m x 2 m sunken bed which was ploughed and harrowed by using hand hoe. The soil was mixed with 20 kg of farmyard manure before sowing. Seeds were sown in the nursery by drilling in rows spaced at 15 cm apart. Seedlings were sprayed once with fungicide (Ivory 72 WP (8% Metalaxyl + 64% Mancozeb manufactured by Arysta LifeSciences, Route d’’ Artix-BP.80, 64150 Nogueres, France)) at the rate of 5 g/L to control damping off disease. Also, insecticide (Selecron (Lambda-cyhalothrin 50 g/L; Uright Enterprise Company Ltd. RMB, 1/F., LAB BLDG, 66 corporation road, Grangetown, Cardiff, Wales, UK) was sprayed once at a dosage of 2 ml/L to control whiteflies and other insect pests. Field preparation was done by using tractor, then, levelling was done by using hand hoe. Ridges were placed 70 cm from one another and spacing between plants was 70 cm. Each experimental plot had 2 rows with 12 plants with an area of 5.88 m^2 (4.2 m x 1.4 m). Treatments were laid out in a complete randomized block design with three replications. Three tomato varieties: Cal J, Meru and Tanya were planted. Seedlings were transplanted 21 days after sowing and fertilizer Di-ammonium phosphate (DAP) was applied before transplanting as basal application at the rate of 5 g/hole equivalent to 50 kg/ha. Split top dressing by using NPK (20:10:10) was applied at rate of 5 g/plant which was equivalent to 50 kg/ha. Although no fungicides were used to control diseases after transplanting, insecticides Selecron and Karate (Karate 5 EC lambda-cyhalothrin, Syngenta Crop Protection, AG, Basle, Switzerland) were used to control insect pests according to manufacturer’s instruction. All tomato seeds, fungicides and insecticides were purchased from agro-dealers in Morogoro municipality. The field experiments were conducted in 2011/2012 and repeated in 2012/2013 during wet seasons at Sokoine University of Agriculture, Morogoro, at latitude of 6˚5’S, longitude of 37˚39’E and an altitude of 524 m. a. s. l. The field was characterized by clay soils.

Diseases assessment: Diseases incidence and severity for tomato early and late blights, Fusarium wilt, Septoria leaf spot and tomato yellow leaf curl were recorded. Data on disease incidence and severity were scored at an interval of 7 days to the maturity of tomatoes basing on visual assessment of symptomatic leaves, petioles, fruits and stems. Disease incidence refers to the proportion of sick plants, while disease severity is the relative or absolute area of plant tissue affected by the disease. Tomato early and late blight diseases severity were scored according to Maerere *et al*. [19] on a scale of 1-4 where; 1 = 0 per cent (no symptoms on the leaf); 2 = < 10 per cent leaf area infected and covered by spots (low severity); 3 = 10-50 per cent leaf area infected and covered by spots, spots also seen on petioles, branches and stems (moderate severity) and 4 = > 50 per cent leaf area infected and covered by spot, spots also seen on petioles, branches, stems and fruits (high severity). Disease severity of Fusarium wilt was assessed by using the scale (0-4) developed by Grattidge and O'Brien [9] whereby; 0 = 0-24% of leaves yellowed and wilted, 1 = 25-49% of leaves yellowed and wilted, 2 = 50-74% of leaves yellowed and wilted, 3 = 75-99% of leaves yellowed and wilted and 4 = 100% of leaves yellowed and wilted. Septoria leaf spot disease severity was assessed by using a 1-5 scale as described by Emua [5] in which: 1 = disease free leaf, 2 = few pin point (<5) lesions on leaf, 3 = large number of lesions on leaf (≥6) but with little coalescence, 4 = large number of lesions (≥6) on leaf with coalescence and senescence/yellowing, 5 = leaf completely destroyed. Tomato yellow leaf curl disease severity was evaluated according to the scale described by Lapidot and Friedmann [18] where 0 = no visible symptoms; 1 = slight yellowing of leaflet margins on apical leaf; 2 = some yellowing and minor curling of leaflet ends; 3 = wide range of leaf yellowing, curling and cupping, with some reduction in size, yet plants continue to develop; 4 = very severe plant stunting and yellowing, pronounced leaf cupping and curling, and plant ceased to grow.

All disease incidence values were calculated using the following formula:

$$\text{Diseases incidence} = \frac{\text{Number of diseased plants}}{\text{Total plants per plot}} \times 100$$

Data analysis: Data on disease incidence and severity were subjected to an arc sine and square root transformation [10] respectively prior to analysis to improve normality. All data were subjected to analysis of variance using the general linear model procedure of the SAS Statistical Package (SAS Institute Inc 1998; Cary, NC, USA.) and treatment means were separated by least significant difference at $P \leq 0.05$.

RESULTS

Results in Fig. 1 show that, Meru differed highly significantly ($P<0.001$) to the other two tested varieties as far as the tomato late blight disease incidence is concerned. On the other hand, Cal J and Tanya had higher tomato late blight disease incidence values and there was no significant difference ($P>0.05$) between them. Meru showed lowest percentage (1.4%) while, Tanya showed highest percentage (82.6%) followed by Cal J (81.2%). Moreover, results show that, Meru differed highly significantly ($P<0.001$) with the other two varieties in terms of tomato late blight disease severity but, the two varieties; Cal J and Tanya had higher severity values and they did not differ significantly ($P>0.05$). The lowest severity value was observed in Meru (1) while the highest value was observed in Tanya (3) and Cal J (3).

Figure 2 shows that there were highly significantly differences ($P<0.001$) varietal reaction towards tomato early blight disease incidences. All tested tomato varieties had higher disease incidence values but, Cal J showed lowest value (65.7%) while, Meru had highest value (82.4%) followed by Tanya (68.5%). In addition, results revealed that there was highly significantly difference ($P<0.001$) between Meru and the other two varieties used in this study as far as tomato early blight disease severity was concerned but, Tanya and Cal J did not differ significantly at $P>0.05$. Cal J and Tanya gave lowest severity value (2) while, Meru was associated with highest severity value (4).

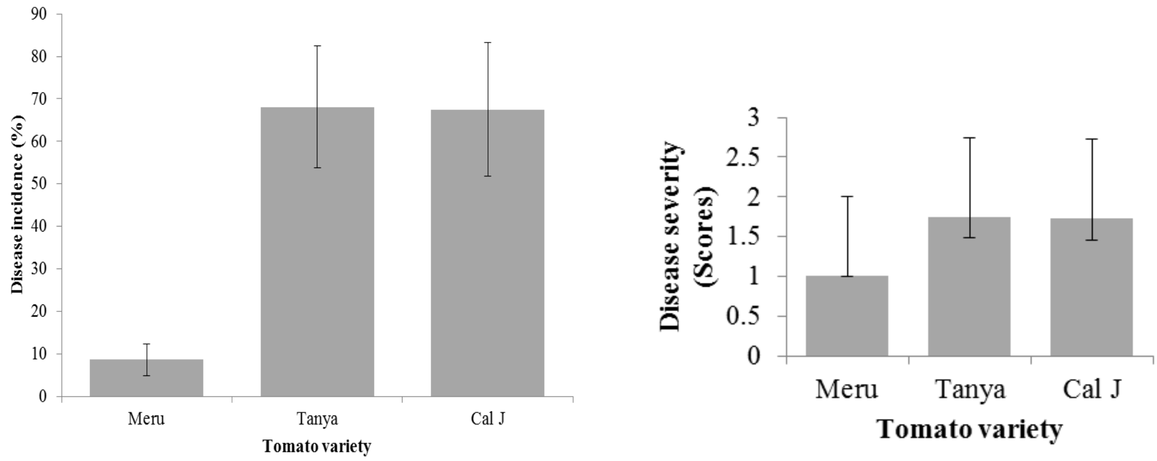

Figure 1: Reaction of varieties to tomato late blight disease. Incidence was the percentage of diseased plants per plot. For disease severity scores 1 = no disease; 2 = <10% blighted leaf area; 3 = 10-50% blighted area and the disease extended to petioles, branches and stems; 4 = >50% blighted area and the disease extended to petioles, branches, stems and fruits

Error bars are standard errors

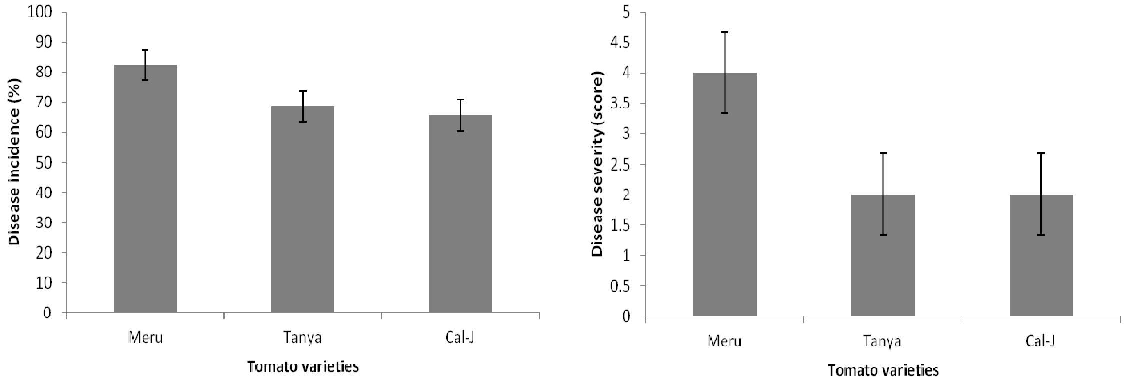

Figure 2: Reaction of varieties to tomato early blight disease. Incidence was the percentage of diseased plants per plot. For disease severity scores 1 = no disease; 2 = <10% blighted leaf area; 3 = 10-50% blighted area and the disease extended to petioles, branches and stems; 4 = >50% blighted area and the disease extended to petioles, branches, stems and fruits

Error bars are standard errors.

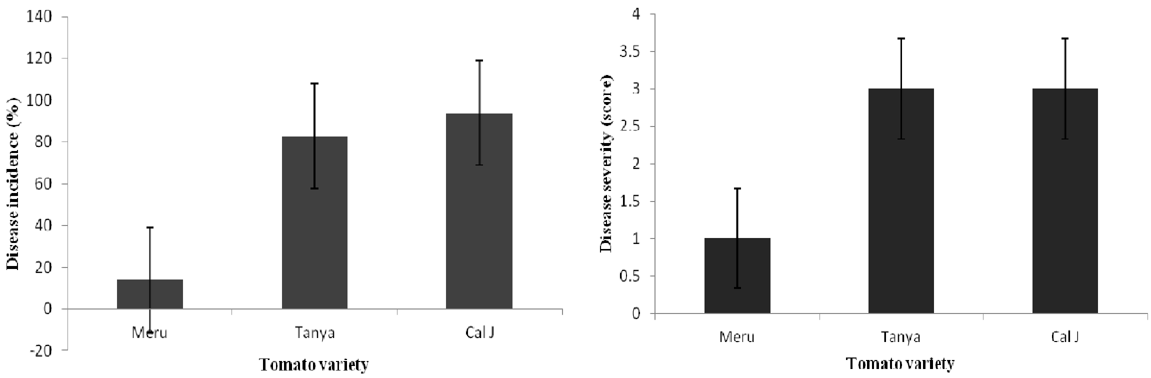

Figure 3: Reaction of varieties to tomato Septoria leaf spot disease. Incidence was the percentage of diseased plants per plot. For disease severity scores 1 = disease free leaf, 2 = few pin point (<5) lesions on leaf, 3 = large number of lesions on leaf (≥6) but with little coalescence, 4 = large number of lesions (≥6) on leaf with coalescence and senescence/yellowing, 5 = leaf completely destroyed

Error bars are standard errors.

Figure 3 shows that there was highly significant difference ($p<0.001$) in terms of Septoria leaf spot disease incidence and severity among the tested tomato varieties. Meru had lowest disease incidence and severity values of 14% and 1, while Cal J had highest values of 94% and 3 followed by Tanya with values of 82.9% and 3 respectively. Disease symptoms in susceptible tomato varieties first appeared on the older, lower leaves and stems when plants reached reproductive stage, particularly at fruit maturity phase (May-June of both seasons).

There were highly significantly difference ($p<0.001$) in Fusarium wilt disease incidence among tomato varieties used in this study (Fig. 4). The lowest incidence was observed in Cal J (34%) and the highest was recorded in Meru (46.3%) followed closely by Tanya (41%). However, results show that, all tomato varieties did not differ significantly ($p>0.05$) in terms of disease severity with score value of 1 implying that, these varieties are equally susceptible to Fusarium wilt disease.

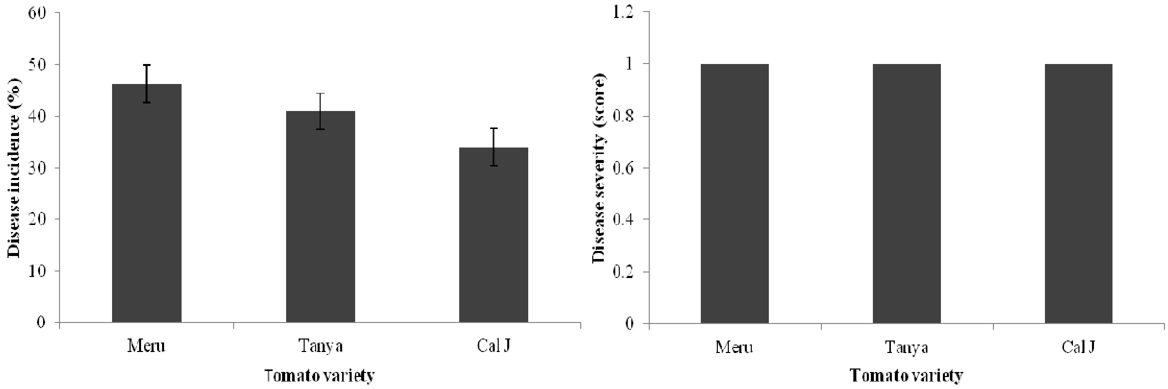

Figure 4: Reaction of varieties to tomato Fusarium wilt disease. Incidence was the percentage of diseased plants per plot. For disease severity scores 0 = 0-24% of leaves yellowed and wilted, 1 = 25-49% of leaves yellowed and wilted, 2 = 50-74% of leaves yellowed and wilted, 3 = 75-99% of leaves yellowed and wilted and 4 = 100% of leaves yellowed and wilted
Error bars are standard errors.

When tomato varieties were compared in terms of tomato yellow leaf curl disease incidence, the highly significantly differences values ($P<0.01$) were observed among them (Fig. 5). The lowest disease incidence was recorded in Meru 29.9% and the highest value was observed in Tanya 46.3% followed by Cal J 40.7%. Despite the differences observed, results revealed that disease incidence was high in all tested varieties. While Meru differed highly significantly ($P<0.001$) with the other two varieties in terms of disease severity, Tanya and Cal J did not differ significantly ($P>0.05$). Meru had low disease severity value of 1 whereas Tanya and Cal J had a slight higher value of 2. Despite the slight differences observed among tomato varieties used in this study, results revealed that disease incidence was high in all varieties. However, these varieties showed moderate disease severity. The disease was first observed in the field six weeks after transplanting. Disease symptoms observed in the field included; leaf curling whereby leaflets curled upwards and reduced internodes which in turn gave the plant stunted appearance with erected shoots.

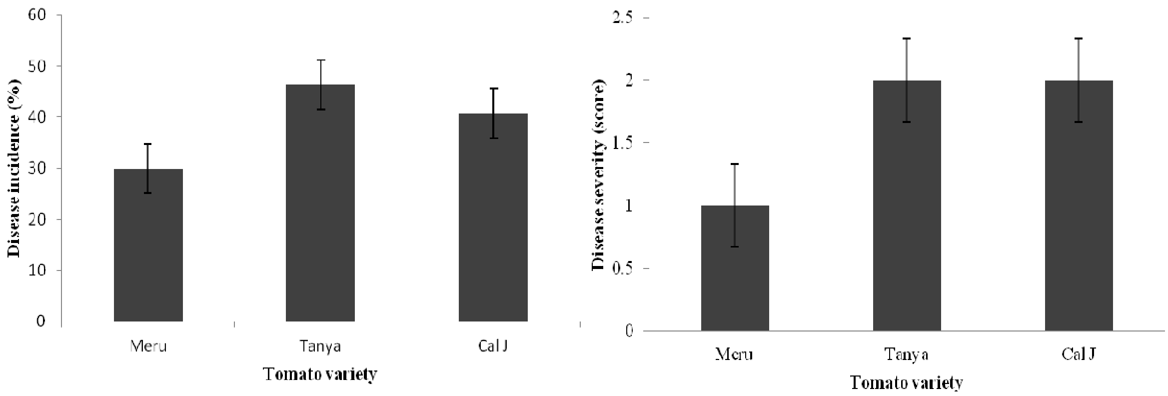

Figure 5: Reaction of varieties to tomato yellow leaf curl disease. Incidence was the percentage of diseased plants per plot. For disease severity scores 1 = slight yellowing of leaflet margins on apical leaf; 2 = some yellowing and minor curling of leaflet ends; 3 = wide range of leaf yellowing, curling and cupping, with some reduction in size, yet plants continue to develop; 4 = very severe plant stunting and yellowing, pronounced leaf cupping and curling, and plant ceased to grow
Error bars are standard errors.

DISCUSSION

Field experiment results indicated that Meru was not significantly affected by tomato late blight disease compared to Cal-J and Tanya. Therefore, the findings of this study confirm that, Meru was resistant to *P. infestans* while varieties Cal-J and Tanya were highly susceptible to tomato late blight disease. Moreover, the higher susceptibility of Cal-J and Tanya to *P. infestans* in our study validates the findings of Cooper and Odour [4], Shaba *et al.* [28] and Masinde *et al.* [21] which reported that varieties Cal-J and Tanya were highly susceptible to the disease. Tomato late blight disease symptoms appeared later during the growing season. They were observed on Tanya and Cal J on 7th week after transplanting when the crop attained reproductive stage. During the period of June to July of both seasons the means minimum and maximum temperatures were 17.8°C and 28.3°C respectively. Also, the whole period was characterized by high relative humidity (88%). Therefore, weather conditions were favourable for *P. infestans* growth and multiplication as the optimum temperature for sporangial formation is 18 to 22°C [6, 8]. Thus, low temperatures favoured *P. infestans* development as the result tomato late blight disease caused most damage in the late cool, humid seasons. William [31], Fontem [6] and Fontem *et al*. [8] similarly reported higher disease incidence and severity as associated with low temperatures and crop developmental stage.

Meru variety was severely infected with tomato early blight disease compared to the other varieties used in the study. This implies that Meru was highly susceptible to the disease than other two varieties whereas, Cal J being less susceptible to the disease. Results are in agreement with the observations reported by Minja *et al.* [22] when evaluating the performance and adaptability of tomato varieties to the eastern coastal areas of Tanzania whereby Meru was highly susceptible to *A. Solani;* a pathogen of tomato early blight disease. Also, Maerere *et al.* [19] when deriving appropriate pest management technologies for smallholder tomato growers in Morogoro region reported similar observation whereby Cal J maintained lower severity of tomato early blight disease compared to Tanya. Tomato early blight disease appeared earlier than other diseases in the field whereby the first disease symptoms were observed on the 5th week after transplanting. The means maximum and minimum temperatures for the first two months (April and May 2011, 2012) were high; 28.7-29.8°C and 20.2-21.1°C respectively. Also, relative humidity during that period was very high (89%). On the other hand, *A. solani* requires high temperatures (28-30°C) and relative humidity (90-100%) for conidial germination and optimal disease development [7]. Therefore, high temperatures and relative humidity during the months of April and May were conducive to the development of the disease. Consequently, tomato early blight disease was more severe in the early part of the cropping season. Similar observations were reported by Fontem [6] and Khan *et al.* [16] whereby tomato early blight disease appeared earlier and was more severe on plants in the early growing season which was characterized by high temperature and relative humidity.

Septoria leaf spot disease symptoms were observed in Cal J and Tanya. Unlike these two varieties, Meru did not show any of the disease symptoms in both seasons. From these observations it is inferred that Meru has genetic resistance to *Septoria lycopersici*, a disease causing pathogen. Disease symptoms in susceptible tomato varieties were observed for the first time in the field 10 weeks after transplanting (mid-May to June of both seasons). Disease build up progressed with crop age and reached high when the crop attained reproductive phase. As a consequence, the disease caused severe leaf destruction which in turn, resulted to significant reduction in both total yield and fruits quality (data not shown) due to reduction in photosynthesis and increased exposure of fruits to sun scald respectively. Maturity phase in both seasons was characterised by high relative humidity (88.5%) and means maximum and minimum temperatures of 28.3-28.7°C and 17.8-20.2°C respectively. From this point of view it is inferred that moderate temperatures and high relative humidity favour disease build up. According to Kumar and Sugha [17], sporangia germination of *Septoria lycopersici* is favoured by high relative humidity and temperature optima of 28-30°C. These observations are in line with those reported by Rizinski [27] and Raina and Razdan [26] that high relative humidity and temperature optima of 20-27°C coincide for disease development.

Results reveal that, Meru suppressed tomato yellow leaf curl disease more when compared to the other two varieties. Thus, Meru was less susceptible against disease causing pathogen than Tanya and Cal J however, all varieties showed moderate disease severity. Both disease incidence and severity increased with crop maturity whereby the highest values were recorded at harvesting stage. Kashina *et al*. [15] made similar observation and reported that tomato yellow leaf curl disease incidence increased rapidly and reached almost 100% at harvest. High disease incidences recorded in this experiment study could be attributed to high population of whiteflies; a vector of *Tomato Yellow Leaf Curl Virus* observed in the field particularly in the months of May and June of both seasons. This period was characterized by high temperatures and reduced precipitations which in turn, favoured vector multiplication.

Also, such a similar observation was made by Kashina *et al*. [14] who reported that hot and dry weather condition favoured the whitefly, and therefore, helped the spread of tomato yellow leaf curl disease. In addition, crop infection from *A. solani* in the early stage of the crop development rendered plant weakness against the virus which facilitated the speed of tomato yellow leaf curl disease development.

Furthermore, all tomato varieties used in this study were susceptible to Fusarium wilt disease. The first disease symptoms were observed in the field six weeks after transplanting. Infected plants were characterized by yellowing of the foliage, beginning with the lower leaves and progressing upward. Yellowing sometimes started on one side of the vine. Infected leaves later showed downward curling, followed by browning and drying. Infected plants were stunted and the degree of stunting was dependent upon time of infection whereby, plants infected during early stage were more severely stunted than plants infected at a later growth stage.

CONCLUSION

Reactions of tomato varieties to common field diseases reveal that variety Meru is resistant to Tomato late blight and Septoria leaf spot. Contrarily, Meru demonstrated high susceptibility to early blight disease when compared to varieties Cal J and Tanya. However, the latter two varieties confirmed high susceptibility to Tomato late blight and Septoria leaf spot diseases. All tested tomato varieties verified moderate susceptibility to Fusarium wilt and Tomato yellow leaf curl diseases. Current survey reports rank variety Tanya as the most popular with tomato growers in the country due to its preferred fruit qualities. However, this variety is susceptible to most field diseases. Therefore, this calls for further genetic improvement for resistance to commonly occurring field diseases.

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