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EVALUATION OF LOCALLY AVAILABLE TOMATO VARIETIES AND INTRODUCTIONS FOR RESISTANCE TO BACTERIAL SPECK AND BACTERIAL SPOT DISEASES IN TANZANIA

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Abstract: Four tomato (*Lycopersicon esculentum* Mill.) varieties commonly grown by tomato farmers in Tanzania were evaluated for resistance to bacterial speck (*Pseudomonas syringae* pv. *tomato*) and bacterial spot (*Xanthomonas vesicatoria*) diseases, along with five introductions under screenhouse and field conditions. The four tomato varieties were Cal J, Moneymaker, Tanya and Roma VF. Seeds of the tomato varieties were purchased from seed vendors in the open market. The introductions that were included in the study were Bravo, Taxman, Stampede (from Sakata-Mayford Seeds (Pty) Ltd, South Africa), Torquay and BSS436 (from Bejo Zaden B.V., The Netherlands). In the screenhouse, results indicated that all the tomato varieties were susceptible to the two diseases, and suffered moderate to severe infection levels. The performance of the introductions against bacterial speck under screenhouse conditions was variable. All the introductions showed high levels of susceptibility to bacterial spot. Under field conditions, incidence of the diseases was high in all the locally available varieties tested, averaging 87% for bacterial spot and 82.3% for bacterial speck. The results of this study indicate that all the locally available tomato varieties included in the study were highly susceptible to bacterial speck and bacterial spot diseases.

Key words: bacterial speck, bacterial spot, tomato varieties, evaluation, resistance

INTRODUCTION

Bacterial speck and bacterial spot diseases of tomato (*Lycopersicon esculentum* Mill.) are caused by *Pseudomonas syringae* pv. *tomato* (Okabe) Young, Dye & Wilkie and *Xan-*

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thomonas vesicatoria (Doidge) Dowson respectively. Together, they are considered to be the most important foliar diseases of tomato in most production areas (Yu et al. 1995; Venette et al. 1996; Blancard 1997). The diseases are commonly found together in mixed infections (Delahaut and Stevenson 2004), causing symptoms that are so similar that they are often confused with each other (Venette et al. 1996). Symptoms appear on leaves, flowers, petioles, stems, and roots. Attack on leaves causes defoliation, resulting in reduced marketable fruit weight (Dougherty 1978; Pohronezny and Volin 1983) and increased exposure of fruits to sun scald. But the main economic effect of the diseases is the reduction in fruit weight and quality. Bacterial spots on fruits have been reported to account for up to 52% loss of fruit weight (Jones et al. 1986), while yield losses due to bacterial speck varied from 75% in plants infected at an early stage of growth to 5% in plants infected later in the season (Yunis et al. 1980).

It is not clear when the diseases were first identified in Tanzania, but field surveys conducted in the country in 1997 and 1998 (Black et al. 2001) showed that bacterial spot of tomato was widespread in tomato and pepper fields in all the vegetable-growing regions of the country. Incidence of the disease was found to vary widely between years and fields, and ranged between < 5 to 90%. Bacterial speck was not detected in tomato seeds and field plants during the surveys. However, recent studies by Shenge et al. (in press) showed that the two diseases were now widespread in farmers' fields in many tomato-producing areas of Tanzania.

Resistance in the host plant has been reported to be the most effective means of management (Yu et al. 1995; Blancard 1997). Other methods of managing the diseases include removal of plant debris, removal of weeds, rotation, and the use of clean (non-infested) seed and transplants (CAB International 2005). Chemical sprays have also been used, but these may not be effective where the weather is favourable for disease development (Somodi et al. 1996). In view of increasing concerns over the long-term negative environmental impact of some pesticides (Stoll 1998; Mew and Natural 1993; Kozik 2002), their rising costs, and increasing development of resistance to some of them by the bacterial speck and bacterial spot pathogens (Bashan 1997; Cooksey and Azad 1992; Pernezny et al. 1995; Silva and Lopes 1995), the search for effective options for managing the diseases has recently focused on cultural methods (Jones et al. 1988; Jones et al. 1983; McGuire et al. 1991) and host genetic resistance to the bacteria (Oldroyd et al. 1997; Kozik 2002). The present study therefore, aimed at evaluating locally available tomato varieties in Tanzania for genetic resistance to bacterial speck and bacterial spot diseases with a view to identifying those which may be used as breeding lines for genetic improvement.

MATERIALS AND METHODS

Screen house experiment

Four locally available tomato varieties in Tanzania, namely; Cal J, Moneymaker, Tanya, and Roma VF were evaluated under screenhouse conditions alongside with five introductions,. The introductions were Bravo, Taxman, Stampede (from Sakata-Mayford Seeds (Pty) Ltd, South Africa), Torquay, and BSS436 (from Bejo Zaden B.V., The Netherlands). Seeds of the tomato varieties were sown in plastic pots of 10 cm diameter filled with sterile soil. The pots were arranged randomly on a bench in a completely randomized design (CRD) with three replications. Ten seeds were sown per pot and later thinned to two plants. At 35 days after sowing (DAS), seedlings were inoculated

by spraying the abaxial and adaxial leaf surfaces with the bacterial suspension adjusted to 10^8 cfu ml^{-1} (Scott et al. 1989) to runoff, using a hand-held sprayer positioned at 20–30 cm from the foliage. Control tomato plants were treated with sterile distilled water (SDW). The inoculated plants were thereafter, covered with a polyethene sheet for 72 h and observed for bacterial speck and bacterial spot symptoms development for up to 14 days. Plants showing symptoms of the two diseases were scored for disease severity three weeks later. Severity scores for bacterial spot were done using the scale of Horsfall and Barret (1945) with modifications as shown: 1 = no disease, 2 = 1–3% infection, 3 = 5–12% infection, 4 = 12–25% infection, 5 = 25–50% infection and 6 = > 50% infection. Severity scores for bacterial speck were obtained by using the scale of Chambers and Merriman (1975) with slight modifications as shown: 1 = no lesions, 2 = 1–10 lesions/plant, 3 = 11–20 lesions/plant, 4 = 21–40 lesions/plant, 5 = more than 40 lesions/plant.

Field experiment

Tomato varieties evaluated under screenhouse conditions were also assessed for resistance to bacterial speck and bacterial spot diseases under field conditions. Seedlings were first raised in a nursery sterile sandy loam soil for 21 days before being transplanted to the field. Plots in the field were 1m wide x 3 m long. Intra-row spacing was 50 cm, while inter-row spacing was 160 cm. A randomized complete block design (RCBD) with four replications was used. Inoculation of the plants and disease evaluation was done as described in the screenhouse experiment.

Results obtained from the screenhouse experiments are presented in Tables 1 and 2, while those from the field experiments are summarized in Tables 3 and 4.

RESULTS

Screenhouse experiment

Results from screenhouse experiments (Tables 1, 2) indicate that all the locally available tomato varieties in Tanzania were susceptible to bacterial speck and bacterial spot diseases. Disease severity scores averaged 4.25 and 4.38 for bacterial speck (Table 1) and bacterial spot respectively (Table 2). The onset of bacterial speck lesions on leaves was as early as 72 h after inoculation, whereas bacterial spot symptom development was slow, taking as long as 7–10 days. The performance of the introductions against bacterial speck under screenhouse conditions was variable (Table 1). However, all the introductions were susceptible to bacterial spot (Table 2). Two introductions from Bejo Zaden B. V. (The Netherlands), Torquay and BSS 436 were resistant to bacterial speck, but not bacterial spot. The reaction of three other introductions from Sakata Mayford, South Africa (Bravo, Taxman, and Stampede) to bacterial speck was variable (Table 1). However, all of them were susceptible to bacterial spot (Table 2).

Field experiment

Results of the field trials (Tables 3 and 4) showed a similar trend to that obtained in screenhouse experiments. Bacterial speck severity on all the locally available tomato varieties under field conditions was similarly high, with an average score of 4.1 (Table 4). However, the severity of bacterial spot was lower in the field than in the screenhouse, with an average score of 2.3 (Table 4). Among the introductions, Torquay and BSS436 were slightly susceptible to bacterial speck (Tables 3 and 4).

Table 1. Evaluation of locally available tomato varieties and introductions for resistance to bacterial speck disease under screenhouse conditions

Serial No.	Treatment	Trial 1		Trial 2	
		HR	disease symptoms*	HR	disease symptoms*
1	Cal J	–	4	–	4
2	Moneymaker	–	4	–	5
3	Tanya	–	5	–	5
4	Roma VF	–	4	–	3
5	Bravo	+/–	+/–	+/–	+/–
6	Taxman	+/–	+/–	+/–	+/–
7	Stampede	+/–	+/–	+/–	+/–
8	Torquay	++	–	++	–
9	BSS 436	++	–	++	–
10	all varieties – SDW	–	–	–	–

HR – Hypersensitive Reaction
*3 – moderately positive, 4 – highly positive, 5 – very highly positive, +/– – variable

Table 2. Evaluation of locally available tomato varieties and introductions for resistance to bacterial speck disease under screenhouse conditions

Serial No.	Treatment	Trial 1		Trial 2	
		HR	disease symptoms*	HR	disease symptoms*
1	Cal J	–	4	–	4
2	Moneymaker	–	4	–	5
3	Tanya	–	5	–	5
4	Roma VF	–	4	–	4
5	Bravo	–	4	–	4
6	Taxman	–	4	–	4
7	Stampede	–	4	–	4
8	Torquay	–	4	–	4
9	BSS 436	–	4	–	4
10	all varieties – SDW	–	–	–	–

HR – Hypersensitive Reaction
*4 – highly positive, 5 – very highly positive

Table 3. Incidence of bacterial spot and speck diseases within populations of various locally available tomato varieties and introductions under field conditions

Serial No.	Tomato variety	Bacterial spot		Bacterial speck	
		1st trial*	2nd trial*	1st trial*	2nd trial*
1	Cal J	75.8 a	100a	100.0 a	100 a
2	Moneymaker	69.4 a	100 a	85.0 a	66.6 ab
3	Tanya	79.1 a	94.1ab	25.0 bc	100 a
4	Roma VF	77.7 a	100 a	82.3 a	100 a
5	Bravo	33.3 d	88.8 ab	66.6 ab	92.4 ab
6	Taxman	42.2 cd	66.6 abc	75.0 ab	44.4 ab
7	Stampede	47.4 bc	55.5 abc	88.5 a	7.4 b
8	Torquay	18.7 e	38.8 bc	13.1 c	8.3 ab
9	BSS 436	54.3 b	29.6 c	50.0 abc	3.3 b
	LSD	10. 47	49.90	46.626	80.550

Means followed by the same superscript are not statistically significant ($p \leq 0.05$) by Duncan Multiple Range Test (DMRT)

Table 4. Severity of bacterial speck and spot diseases within populations of locally available tomato varieties and introductions under field conditions

Serial No.	Tomato variety	Bacterial speck		Bacterial spot	
		1st trial*	2nd trial*	1st trial*	2nd trial*
1	Cal J	4.0 abc	5.0 a	2.3 a	3.0 n.s.
2	Moneymaker	5.0 a	3.0 cde	2.3 a	2.0 n.s.
3	Tanya	3.7 bcd	4.0 abc	2.0 ab	2.0 n.s.
4	Roma VF	4.3 ab	4.0 abc	2.0 ab	3.0 n.s.
5	Bravo	4.0 abc	4.3 ab	2.3 a	2.7 n.s.
6	Taxman	3.0 cde	3.3 bcd	2.3 a	2.0 n.s.
7	Stampede	2.7 de	2.6 de	2.0 ab	2.0 n.s.
8	Torquay	3.7 bcd	2.0 e	1.3 b	2.0 n.s.
9	BSS 436	2.7 de	2.0 e	2.0 ab	2.0 n.s.
	LSD	1.079	1.065	0.708	0.313

n.s. – no significant differences

Means followed by the same superscript are not statistically significant ($p \leq 0.05$) by Duncan Multiple Range Test (DMRT)

It has been reported that host genetic resistance is the most effective method of managing bacterial speck and bacterial spot diseases of tomato (Scott et al. 1989; Yu et al. 1995; Blancard 1997).The findings of this study, therefore, revealed the precarious position of tomato growers in Tanzania. None of the tomato varieties grown was resistant to the bacterial speck and bacterial spot diseases (Tables 1–4). The results also corroborate the findings of earlier studies which reported widespread occurrence of bacterial speck and bacterial spot diseases on farmers' fields throughout the tomato-producing areas in Tanzania (Black et al. 2001; Kaaya et al. 2003; Shenge et al., in press).

Development of disease resistant tomato genotypes is the most efficient and environmentally friendly way to control the two disease when sufficient genetic variation for resistance is available (Hulbert et al. 2001). Resistance genes are unique in that they have evolved to respond to many different plant defence systems/mechanisms. The tomato variety Hawaii 7998 has been reported to be the only reliable source of resistance to Race 1 strains of *X. vesicatoria* (Scott and Jones 1986). The incorporation of the genes in H7998 responsible for resistance into commercially acceptable tomato genotypes is now a common practice (Scott et al. 1989). In the tomato-bacterial speck pathosystem, the resistance (*R*) gene to the pathogen was originally discovered in wild-type species of tomato (*Lycopersicon pimpinellifolium*). Resistance to race 0 of *P. syringae* pv. *tomato*, conferred by this gene has been introduced into several tomato varieties by backcrossing.

Although tomato cultivars with resistance to some races of the bacterial speck and bacterial spot pathogens have been developed, some drawbacks exist in their exploitation. The main drawback is that development of resistant tomato genotypes through traditional breeding techniques takes a long time. Another challenge associated with the use of genetic resistance is that its effects may not be durable due to genetic shifts in the pathogen population. To overcome this problem, breeding for resistance to bacterial speck and bacterial spot diseases should target resistance genes that have been known to interact with important or widespread *avr* genes. An example is the recently isolated *Bs2* gene from pepper (Tai et al. 1999), whose cognate *avr* gene is very widespread in *Xanthomonas*, and is also a virulence factor (Kearney and Staskawicz 1990). Once such genes are successfully incorporated into commercially acceptable tomato genotypes, the durability of the resulting disease resistance may be reasonably guaranteed.

Additionally, development of resistant tomato varieties should take into account consumer preferences. It has been reported that the tomato variety Tanya (also known as dum dum) was and is popular with tomato farmers in Tanzania (Shenge et al., unpublished). This variety was popular due to its preferred fruit qualities, which included firmness, longer shelf life, taste, ability to withstand relatively rough post-harvest handling with minimal damage, and the absence of cracking. Tanya is also an indigenous variety, with good adaptation to the local environment. Unfortunately, it is also highly susceptible to bacterial speck and bacterial spot diseases (Tables 1–4). Its aboriginal status, good environmental adaptation, and commercial acceptability, recommend it as an excellent candidate for genetic improvement for resistance to these diseases.

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POLISH SUMMARY

OCENA ODPORNOŚCI DOSTĘPNYCH I INTRODUKOWANYCH ODMIAN POMIDORA NA BAKTERYJNĄ CĘTKOWATOŚĆ (*PSEUDOMONAS SYRINGAE* PV. *TOMATO*) I BAKTERYJNĄ PLAMISTOŚĆ (*XANTHOMONAS VESICATORIA*) W TANZANII

Oceniano odporność 4 odmian pomidora (*Lycopersicon esculentum* Mill.) uprawianych przez farmerów w Tanzanii oraz 5 odmian introdukowanych na bakteryjną cętkowatość (*Pseudomonas syringae* pv. *tomato*) i bakteryjną plamistość (*Xanthomonas vesicatoria*). Doświadczenia prowadzono w warunkach polowych oraz pod osłoną, na występujących 4 odmianach: Cal J, Moneymaller, Tanya i Roma VF. Do badań wykorzystano nasiona dostępne w handlu. Jednocześnie oceniano odporność 5 odmian introdukowanych: Bravo, Taxman, Stampede (z Sakata-Mayford Seeds (Pty) Ltd. Południowa Afryka), Torquay i BSS436 (z Bejo Zaden B.V. Holandia). Wyniki uzyskane pod osłoną wskazywały na wrażliwość wszystkich odmian lokalnych na obydwie choroby, przy czym porażenie oceniono jako umiarkowane do silnego. Wyniki badań odporności introdukowanych odmian na bakteryjną cętkowatość, powodowanych pod osłoną były zmienne. Wszystkie odmiany introdukowane wykazały wysoki poziom wrażliwości na bakteryjną plamistość. W warunkach polowych występowanie chorób na odmianach lokalnych było pospolite i wynosiło 87% dla bakteryjnej plamistości i 82,3% dla bakteryjnej cętkowatości. Wyniki przeprowadzonych badań wykazały, że wszystkie lokalnie dostępne odmiany, które uwzględniono w badaniach, były bardzo wrażliwe na obydwie choroby bakteryjne.