Seasonal Variations in Incidence and Severity of Bacterial Spot and Bacterial Speck of Tomato (*Solanum lycopersicum* L.) Under Rain-Fed and Irrigated Conditions In Samaru Zaria, Nigeria

Shenge, K.C.[2], Jimoh, R.O.[1],Akpa, A.D.[1], Chindo, P.S.[1] and Ajene, I.J.[1*]

[1]Department of Crop Protection, Faculty of Agriculture/Institute for Agricultural Research, Ahmadu Bello University, Zaria.[2]School of Plant Sciences USDA-Agricultural Services University of Arizona Tuscon U.S.A. *Corresponding author, email:inusaajene@yahoo.com, ijajene@abu.edu.ng

Summary

Tomato production is hampered by many constraints, including insect pests and diseases. Among the important diseases are bacterial spot and bacterial speck, caused by *Xanthomonas vesicatoria* and *Pseudomonas syringae* pv. *tomato*, respectively. These diseases have been reported to cause remarkable yield loss in all tomato producing areas. This study was therefore undertaken to evaluate the reaction of some tomato varieties to bacterial spot and bacterial speck diseases under screenhouse and field conditions and determine the seasonal variation in the incidence and severity of the disease on the field under natural infection. Screenhouse experiments were carried out in a completely randomized design while field experiments were done using randomized complete block design. Four tomato varieties (Roma VF, UC - 82, Tima and Rio Grande) were evaluated, and Koch's postulate was confirmed to ascertain infection by the pathogens. The results indicated that all seed samples obtained from farmer saved stocks were infected with bacterial spot while those from the open markets/certified seed vendors were not infected with the pathogen. Among the varieties evaluated for resistance, none was resistant to the pathogens with Rio Grande being the most tolerant. On the field, incidence (35.0%) and severity (1.6±0.17) of bacterial spot was more severein the wet season than in the dry season in

2010/2011 also incidence (33.0%) and severity (1.7±0.23) of bacterial spot was more severein the wet season than in the dry season of 2011/2012 while bacterial speck was also not detected in both seasons.

Keywords: Bacterial spot, Bacterial speck, Incidence, severity, Tomato diseases

TOMATO (*Solanum lycopersicum* Mill) is a crop of great importance in Nigeria and the world over, because of its popularity and versatility in fresh and processed forms, as well as its adaptability as a horticultural crop (15). Its importance is largely due to its nutritional significance as being rich in lycopene and as a source of vitamins A and C. Lycopene is an important antioxidant present in ripe red tomato fruit which has some anticancer property (7). The plant is also highly adaptive to diverse environmental conditions, making it possible for its cultivation all year round in most parts of the world (13). Tomato is cultivated mostly in the northern states of Nigeria (8). Despite the increase in tomato production in Nigeria, average yields were just 57.8 tons/ha in 2012, which was much lower than the average global yield of 336.8 tons/ha (5). These losses are partly due to activities of insect pests and diseases (4). Diseases caused by fungi, bacteria, nematodes and viruses count for a significant portion of the yield losses on tomato (16). Bacterial spot (*Xanthomonas campestris* pv. *vesicatoria*) and bacterial speck (*Pseudomonas syringae* pv. *tomato*) are among the major bacterial diseases affecting tomato in all tomato-growing regions of the world. The efficiency of pathogen infection, symptom development and yield responses of host plants are greatly influenced by environmental conditions such as temperature and light variations, seasons of the year, nutrition and water supply. For phytobacterial pathogens, environmental conditions have a significant impact on their survival and proliferation, since they are non-spore-forming (6). Almost all varieties of tomato are highly susceptible to diseases, especially during the wet season. This a daunting challenge to increasing production especially in the tropics where the diseases are extremely difficult to control under the moist and warm conditions prevalent in tropical and subtropical tomato growing regions. In general, seasonal climatic change is one of the key factors that influence disease infection, because if the climatic conditions are not

favourable,infection may not be established (3).

The objectives of this study were to determine the prevalence and seasonal variation in the occurrence of bacterial spot and bacterial speck on tomato, and to screen some locally available varieties for resistance to bacterial spot and bacterial speck diseases.

MATERIALS AND METHODS

Study Location

Zaria lies between Latitude 11º03′ N and11º15′ N; Longitude 7º30′ E and 7º45′ Eand *altitude* of 550-700 meters in Kaduna State. The town experiences distinct wet and dry seasons. The wet season (May-October) is characterized by convectional rainfall with a mean annual rainfall is about 1000 mm. The dry season (November - April) is characterized by a period of low temperatures (21ºC) (December-February) and the hot, dry season (March - April) where temperatures are as high as 32ºC. Relative humidity is high during the rainy season (75%) but decreases during the dry season (21%), (12).

The screenhouse experiment was conducted in the Department of Crop Protection while the field experiments were carried out on the Institute for Agricultural Research (IAR) Research Farms in Samaru, Zaria. Four tomato varieties were used in the experiment namely Roma VF, UC- 82, TIMA and Rio Grande. Sterile soil was used in the screenhouse experiments to prevent contamination by other pathogens.

Screenhouse Experiment

Preparation of bacterial Inoculum and inoculation of tomato seedlings

Pure cultures of *Xanthomonas campestris* pv. *vesicatoria (Xcv)* and *Pseudomonas syringae* pv. *tomato (Pst)* were obtained from the Bacteriology laboratory at the Crop Protection Department of the Faculty of Agriculture, Institute for Agricultural Research, Ahmadu Bello University Zaria. Identification of the bacterial pathogens was done using physiological tests, (Gram reaction and hypersensitive reaction), and growth characteristics on selective media (Kings Media B (KB) for *Pst* and Yeast Dextrose Carbonate agar (YDC) for *Xcv* respectively). The petri dishes were then incubated at 25 – 28 ^{o} C and examined daily. When colonies had formed on the petri-dishes, they were harvested to prepare individual bacterial suspensions that were adjusted to a concentration of 10^{8} cfu ml^{-1} for inoculation of the tomato plants.

Screening varieties of tomato for resistance to bacterial spot

Four varieties, namely; Roma VF, UC-82, Tima, Rio Grande, were evaluated under screenhouse conditions for resistance to the bacterial spot. Seedlings of each variety were raised in 14.75× 8.25×1 inches trays containing sterile sandy-loam soil and transplanted at 21 days after sowing (DAS) into plastic pots (15cm diameter ×14cm depth). The pots were arranged on a bench in a completely randomized design (CRD) with three replications. At 35 DAS, seedlings were inoculated with *Xanthomonas campestris* pv. *vesicatoria* suspension using the aerosol method in which the abaxial and adaxial leaf surfaces were sprayed to runoff. Plants treated with sterile distilled water (SDW) served as control.

Screening varieties of tomato for resistance to bacterial speck diseases

Four varieties, namely; Roma VF, UC-82, Tima, Rio Grande, were evaluated under screenhouse conditions for resistance to bacterial speck. The same procedure as described above was repeated. At 35 DAS, seedlings were inoculated with the bacterial suspension (*Pseudomonas syringae* pv. *tomato*) using aerosol method. Plants serving as control were treated with sterile distilled water (SDW).

Plants were thereafter observed for the expression of a hypersensitive reaction or typical bacterial speck and spot symptoms between 3 and 4 days after inoculation (DAI). At 14 days, plants were scored for disease severity using the scale described by (14).

Data collected were analyzed using the analysis of variance (ANOVA) on the SAS package. Treatment means were separated using Least Significant Difference (LSD) at 5% level of significance. All the experiments were repeated twice. The experiments were carried out both in the wet and dry season. A combined analysis of the two seasons on each parameter was done.

Field Survey

Determination of the occurrence of bacterial diseases of tomato.

Experiments were conducted at Institute for Agricultural Research Samaru in August and November of 2010 and 2011 representing the rainy and dry seasons respectively. The following varieties namely; Roma VF, UC-82, Tima and Rio Grande, were planted on the field with recommended spacing (1.5 m wide × 3 m long with intra row spacing of 45cm while inter row spacing was 75cm). Disease incidence was determined by

taking the percentage of the ratio of the total number of diseased plants to the total number of plants examined.

$$\text{Disease incidence} = \frac{\text{Total number of diseased plants}}{\text{Total number of plants examined}} \times 100$$

$$\text{Disease severity index} = \frac{\text{sum of individual plant rating}}{\text{Total number of plants assessed x maximum score}} \times 100$$

Disease severity of bacterial spot was scored using a scoring scale described by (14) where;

1 = no disease, 2 = 1-3 % infection, 3 = 5-12 % infection, 4 = 12-25 % infection, 5 = 25-50 % infection and 6 = above 50 % infection.

Disease severity of bacterial speck was scored using scale described by (14) where;

1= no lesions, 2= 1-10 lesions on leaves, 3=11-20 lesions on leaves, 4=21-40 lesions on leaves, 5=more than 40 lesions on leaves.

Diseases were assessed in August (rainy season) and November (dry season) of 2010 and 2011 to compare variations in the levels of disease incidence and severity.

RESULTS

Results from screenhouse experiments showed that all the tomato varieties were susceptible to bacterial spot and bacterial speck diseases. Their susceptibilities were however not severe (Tables 1 and 2). In screening for resistance to bacterial spot, there was no significant difference between the varieties (Table 1). A similar trend was observed when screening for resistance to bacterial speck, with no significant difference between the means (Table 2).

In determining the occurrence of bacterial diseases of tomato, in the first year, Roma VF had the highest incidence of bacterial spot on both leaves and fruits while Rio Grande had the lowest incidence in the wet season (Table 3). The difference between the varieties with highest incidence and lowest incidence was significant. With severity of disease on leaves, there were no significant differences in the wet season but the difference among the varieties in the dry season was significant. In the dry season however, Roma VF and UC-82 had highest incidence on leaves with Tima and Rio Grande having no incidence of infection on the leaves (Table 3). In the dry season, there was no disease incidence on the fruits.

In the second year, the incidence and severity of the diseases on leaves and fruits followed a similar trend, but there were no significant differences among the varieties in both the wet and dry seasons (Table 4). There was no incidence of bacterial speck in both seasons on any of the varieties grown (Tables 3 and 4).

Table 1: Reaction of tomato varieties to bacterial spot under inoculation at Samaru.

Tomato variety	Disease severity at 14 DAI		Combined Mean
	2010		
Roma VF	3.00a	2.30a	2.65a
UC- 82	3.30ab	2.30a	2.80a
Tima	3.00a	2.00a	2.50a
Rio Grande	3.00a	1.70ab	2.35a
Control	1.00 b	1.00b	1.00b
SE	0.20	0.22	0.21

All means with the same letter show no significant difference at 5% level of probability

SE = Standard error

DAI = Days after inoculation

Table 2: Reaction of tomato varieties to bacterial speck under inoculation at Samaru.

Tomato variety	Disease severity at 14 DAI		Combined Mean
	2010	2011	
Roma VF	2.30a	2.00a	2.15a
UC- 82	3.00ab	1.70a	2.35a
Tima	2.00a	1.70a	1.85a
Rio Grande	2.00a	1.70a	1.85a
Control	1.00b	1.00b	1.00ab
SE	0.27	0.13	0.20

All means with the same letter show no significant difference at 5% level of probability

SE = Standard error

DAI = Days after inoculation

Table 3: Incidence and severity of bacterial spot on tomato varieties, 2010/2011 wet and dry seasons

Tomato variety	Wet Season				Dry Season			
	Leaves		Fruits		Leaves		Fruits	
	Incidence (%)	Severity	Incidence (%)	Severity	Incidence (%)	Severity	Incidence (%)	Severity
Roma VF	23.7a	1.6a	35.0a	1.2a	4.0a	1.4a	0a	0a
UC- 82	18.0ab	1.5a	20.3ab	1.1a	4.0a	1.3ab	0a	0a
Tima	16.7ab	1.4a	10.3ab	1.0a	0a	1.3ab	0a	0a
Rio Grande	4.0b	1.3a	0a	1.1a	0a	1.0a	0a	0a
SE	2.53	0.17	4.55	0.01	1.1	0.17	-	-

All means with the same letter show no significant difference at 5% level of probability

SE = Standard error

Table 4: Incidence and severity of bacterial spot on tomato varieties, 2011/2012 wet and dry seasons.

Tomato variety	Dry Season				Wet Season			
	Leaves		Fruits		Leaves		Fruits	
	Incidence (%)	Severity	Incidence (%)	Severity	Incidence (%)	Severity	Incidence (%)	Severity
Roma VF	33.0a	1.7a	21.0a	1.0a	10.0a	1.4a	0a	1.1a
UC- 82	27.7a	1.6a	14.0a	1.0a	4.0a	1.2a	0a	1.0a
Tima	23.7a	1.5a	6.3a	1.1a	0a	1.1a	0a	1.0a
Rio Grande	21.3a	1.4a	0a	1.1a	0a	1.0a	0a	1.0a
SE	5.28	0.23	4.25	0.05	2.36	0.05	-	-

All means with the same letter show no significant difference at 5% level of probability

SE = Standard error

DISCUSSION

This study was aimed at evaluating the reactions of some tomato varieties to bacterial spot and speck diseases which are among the major diseases affecting tomato worldwide and determining the seasonal variations if any of the disease.

The results from the screenhouse experiments showed that all the varieties screened were susceptible to bacterial spot and bacterial speck diseases. This agrees with (3) who observed that almost all varieties of tomato are highly susceptible to diseases, especially during the wet season. The incidence and severity of the disease in the field studies showed that the bacterial spot was prevalent in the wet season and less so in the dry season, implying that the pathogen was more prevalent in the wet season as a result of favorable weather conditions suitable for disease development. This agrees with (6) who observed that favorable environmental conditions facilitate disease expression with a significant impact on their survival and proliferation. However, in the dry season, the spot symptoms were less severe on the leaves and were not expressed on the fruits suggesting that the environmental conditions play a critical role in the disease expression and pathogen proliferation.

In Nigeria, (9) observed about 5 per cent loss of marketable fruits due to bacterial diseases. (11) further reported crop yield losses of 50%. To estimate the yield losses, (10) conducted several field trials and found that marketable fruit yield was reduced by 30 percent in control plots as compared to treated plots as a result of the disease infection. In Tanzania, (2) reported that a survey of tomato fields (from 1997 – 1998) showed that bacterial spot of tomato was widespread in all the vegetable-growing regions of the country. The findings of this study showed that bacterial spot is wide spread while bacterial speck was not detected in tomato fields at the time the experiments were carried out. Although the results do not 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 by (14), as an emerging disease in Nigeria, bacterial speck is not endemic to the study area yet, but a more comprehensive study in a diverse range of agro-ecologies will provide a clear overview of the distribution of the disease in Nigeria.

CONCLUSION

This work has shown that the incidence and severity of bacterial spot diseases in the dry season is less than that of the wet season while bacterial speck was not detected in the study area. It is therefore advisable that farmers in Nigeria should adhere to dry season production of tomatoes. However, since wet season production is inevitable, farmers should use the least susceptible variety (Rio Grande). This study also revealed that among the varieties screened for resistance, none of them showed any resistance to the pathogens. As much work is yet to be carried out on yield loss assessment on bacterial speck disease of tomato in Nigeria, more research should be carried out on epidemiology and yield loss assessment of both diseases. More indigenous varieties should also be subjected to research to develop disease resistant genotypes that are suitable for use by farmers in Nigeria.

Systemic efforts are warranted to undertake studies on aspects of epidemiology and assessment of losses caused by these diseases. There is also an urgent need to combine integrated disease management techniques combining the use of various cultural practices, chemicals, bio-agents and host resistance which would be cost effective and provide disease free tomato.

REFERENCES

1. **Anonymous 2013.** The Great Tomato Waste in Nigeria. http://kalusam.wordpress.com/2013/09/11/the -great-tomato-waste-in-nigeria/ (Accessed 19th October 2014**)**
2. **Black R., Seal S., Abubakar Z., Nono-Womdim R., Swai I. 2001.** Black spot (*Xanthomonas campestris* pv. *vesicatoria*) of tomato and sweet pepper in Tanzania. *Plant Pathol*. 50, p. 810.
3. **Fajinmi, O. B., Arogundade, O., Amosu, S. A., Adeoye, P. O. and Olaleye, O. 2012.** Seasonal changes as it affects the incidence of viral and fungal diseases of tomato. Continental J*ournal of Agricultural Sciences* 6(2):18-22.
4. **Fajinmi, A. A. and Fajinmi, O. B. 2010.** An overview of bacterial wilt disease of tomato in Nigeria. *Agricultural Journal*, 5(4): 242-247
5. **FAOSTAT 2014.**http://www.faostat.fao.org/site/339/default.aspx. (Accessed on 16th July 2014)
6. **Garrity, G. M., Bell, J. A. and Lilburn, T. G. 2004.** Taxonomic outline of the Prokaryotes: Bergeys manual of Systematic Bacteriology, Second Edition, Release 5.0. Springer, New York Incorporated. P401
7. **Ibitoye, D. O., Akin-Idowu P. E. and Ademoyegun O. T. 2009.** Agronomic and Lycopene Evaluation in Tomato. (*Lycopersicon lycopersicum* Mill.) as a Function of Genotype.

Retrived from idosi.org/wjas/wjas5(S)/13.pdf.

8. **Idah, P. A., Ajisegiri, E. S. A. and Yisa, M. G. 2007.** Fruits and vegetables handling and transportation in Nigeria.*African Union Journal of Technology*, 10(3): 175-183**.**
9. **Okoli, C. A. N. and Erinle, J.D. 1989.** Factors responsible for market losses of tomato fruit in the Zaria area of Nigeria. *Journal of Horticultural Science.* 64(1): pp 69-71.
10. Pernezny, K. and Zhang, S. 1994. Tomato disease management: Bacterial speck of tomato *University of Florida, IFAS Extension, Extension Plant PathologyPointer* No. 10.
11. **Pohronezny, K. L., Moss, M. A., Dankers, W and Schenk, J.1990.**Dispersal and management of *Xanthomonas campestris pv. vesicatoria* during thinning of direct seeded tomato. *Plant Dis*. 74. pp 800-805**.**
12. **Sawa B. A. and Buhari, B. 2011.** Temperature Variability and Outbreak of Meningitis and Measles in Zaria, Northern Nigeria. Research Journal of Applied Sciences, Engineering and Technology, 3(05): 399-402.
13. **Shankara N., Van Lidt de Jeude J., De Goffau M., Martin H. and Van Dam B. 2005.** Cultivation of Tomato; Production, Processing and Marketing. Agrodok 17. Barbara van Dam (ed.). Fourth completely revised edition**.**
14. **Shenge K. C.,Mabagala B. R. and Mortensen N. C. 2007.** Evaluation of locally available tomato varieties and introduction for resistance to bacterial speck and bacterial spot diseases in Tanzania. *Journal for plant Protection research,* Vol. 47, No. 2.
15. **Stall R. E. and Zitter T.A. 1991.** *Compendium of Tomato Diseases*. (Jones J. B Jones P J (eds). APS Press 2-3.
16. **Tolman, J. H., McLeod, D. G. R. and Harris, C. R. 2004.** Cost of crop losses in processing tomato and cabbage in south western Ontario due to insects, weeds and/or diseases. *Canadian Journal of Plant Sciences,* 84: 915-921
17. **Wokoma, E. C. W. 2008.**Preliminary report on diseases of tomato in Choba, Rivers state.*Journal of Applied Sciences and Environmental Management*, 12(3): 117-121