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Response of Field-grown Genotypes of Tomato to Naturally Occurring Virus Diseases under Tropical Conditions

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Abstract

Genetic make-up of plants, to an extent and seedling vigour have been regarded as conditions of active good health that aids rapid germination, disease tolerance and natural robustness in yield increase. Therefore, considering tomato genotypes, clear differences in the seedling vigour may translate to agronomic performance with regards to yield and disease incidence of each of the genotypes. There is the need to establish what these differences are and the beneficial effects of the variations in tomato vigour. The effects of naturally occurring viral diseases were observed on 4 hybrids and 4 local tomato (*Solanum lycopersicum* L.) genotypes. The seedlings were raised in nursery for a period of 4 weeks and the vigour monitored before transplanting to the field. Data were collected on the plant height, number of leaves, days to 50% flowering and fruiting, number of fruits produced per plant, yield per plant and yield per hectare and virus disease incidence. The seedling vigour varied among genotypes and was associated with decreasing incidence of viral disease. All genotypes were susceptible to viral diseases at various degrees. The percent increase in incidence of viral disease was directly associated with reduction in number of leaves and plant height. The Increase in disease incidence among genotypes was associated with reduction in yield.

Keywords: *Solanum lycopersicum* L., incidence, susceptible, vigor

Introduction

Plant pathogenic viruses cause major diseases in tomato (*Solanum lycopersicum* L.) (Fazeli *et al*., 2009). According to Brunt *et al*. (1995), most viral diseases cause stunted growth, leaf distortion, mosaic leaf dis-colouration and spots or dis-colouration on fruit. Viral diseases are mostly transmitted by insect vectors and the severity of a virus disease is usually tied to the population fluctuations of these vectors (Fajinmi *et al*., 2011). Viral pathogens of tomato diseases are of different genera. The genus *Begomovirus* encompasses the causative agents of tomato spotted wilt disease, tomato yellow wilt disease (Kings *et al*., 2012) and the genus *Tobamovirus* compasses of tomato mosaic viral pathogens that are prominent in Nigeria (Arogundade *et al*., 2007). Viral diseases remain notoriously difficult to control due to its short generation time and the ability to quickly evolve, develop and adapt under natural selection pressure (Fajinmi and Odebode, 2007; Fajinmi and Odebode, 2010). However, the use of resistant varieties is the best option but the development of genetic resistance is time consuming and will, in most cases, become available only after the virus has become well established (Hanssen *et al*., 2010). The genetic makeup has an influence on seedling vigour (N'diaka and Gebisa, 2003). There are differences in vigour, which exist among different species, genotypes and even varieties of the same species (N'diaka and Gebisa, 2003). The

differences in seedling vigour can translate to improved performance with regards to yield and disease incidence (Dias, 2011). Hence, this justifies the need to establish, in clear terms, what these differences are and the beneficial effects of the variations in vigour to disease occurrence and yield performance. With this in mind, this study set out to determine the incidence of viral diseases on some tomato genotypes and to establish the relationship between viral disease incidences, seedling vigor and fruit yield of the tomato genotypes.

Materials and Methods

Eight tomato genotypes (4 hybrid and 4 local tomato genotypes) were used for this study. The hybrid tomato genotypes used were; 'F1 Cobra 26', 'F1 Lindo', 'Panther 17F1' and 'Roma Savanna'; local tomato genotypes used were; 'Hausa', 'Tiwantiwa', 'Beske' and 'Agbara'. The varieties were selected on the basis of yield potential, quality and market acceptability. Ninety (90) seedlings of each genotype were raised in a sterilized manured soil contained in 5 L round nursery bowls covered with an insect-proof net in an insect-proof nursery cage for a period of 4 weeks. At transplanting, the treatments were replicated 3 times in a randomized complete block design (RCBD).

To determine the seedling vigour, data were collected on percentage seedling emergence which was taken by physical counting of emerged seedlings at 6, 9, 12, and 15 days after sowing. The seedling vigor (SV) was estimated as:

$$SV = \frac{\%\ \text{Seedling emergence}\ xPlumule\ length}{100}$$

where: Seedling emergence (SE)

$$SE = \frac{Number\ of\ normal\ seedlings\ (first\ count)}{Days\ of\ first\ count} + \frac{Number\ of\ normal\ seedlings\ (final\ count)}{Days\ of\ final\ count}$$

To determine the plumule length, a meter rule was used to measure the stem height from the soil surface to the apical shoot (AOSA, 1983). Data on the plumule length were also recorded at 6, 9, 12 and 15 days after sowing. Data were analyzed using analysis of variance (ANOVA) with SAS package 1999. The means were separated using least significant difference (LSD) test at 5% level of probability (Steel *et al.*, 1997).

Field data were collected once a week from 6 to 10 weeks after transplanting on plant height, number of leaves, days to 50% flowering and fruiting, number of fruit per plant, yield per plant and yield·ha^{-1}. Percentage virus disease incidence was estimated by dividing the number of infected plants per plot by the total number of plants in that plot multiplied by the total plant population in that plot (Fajinmi, 2011). Data were subjected to analysis of variance. If interactions were significant they were used to explain results. If interactions were not significant the means were separated using Tukey's test. Correlation analysis was employed to estimate the degree of association between seedling vigor, disease incidence, yield and other variables. Path coefficient analysis was used to partition the correlation into direct and indirect effects of the variables on yield.

Results

Seedling vigour was highest for 'F1 Cobra 26' which did not differ significantly from 'Panther and 'F1 Lindo' that gave similar values followed by 'Roma savannah' and 'Agbara'. The least vigorous seedlings were 'Beske', 'Hausa and 'Tiwantiwa' with similar values. Table 1 and Fig 1 shows the virus incidence in the tomato genotypes. At 6 WAT there was no virus disease incidence in 'Roma Savannah' and 'Tiwantiwa' but 'F1 Lindo had 8, 88% incidence while 'Hausa had 4.45% disease compared with other genotypes that had 6.67% viral disease incidence. At 7 WAT, the virus disease incidence increased in all the genotypes except in 'Tiwantiwa' with no disease incidence. 'Beske', 'F1 Cobra' and 'Roma Savannah' genotypes had 6.67% virus disease incidence, while 'F1 Lindo' and 'Panther 17 FI and 'Tiwantiwa' were significantly ($p \leq 0.05$) different from other tomato genotypes with highest and lowest percentage incidence of virus disease (53.33% and 0%) respectively.' 11.09% incidence. At 8 weeks 'Tiwantiwa' still had no virus disease incidence while 'F1 Lindo' and F1

Cobra 26' showed incidence of 18.1 % and 16.34% respectively but there was rapid increase in virus disease incidence in all the other tomato genotypes. 'Panther 17 FI' and 'Tiwantiwa' were significantly ($p \leq 0.05$) different from other tomato genotypes with highest and lowest percentage incidence of virus disease (53.33% and 0%) respectively. At 9WAT there was increase in the virus disease incidence in all the tomato genotypes with 'Tiwantiwa' recording 36.31% disease incidence. At 10 WAT, 'F1 Cobra 26' and 'Tiwantiwa' had the least incidence of virus disease (24.3% and 40.89%) respectively and were both significantly ($p \leq 0.05$) different from other tomato genotypes while 'Panther17F1' had the highest virus disease incidence (75.95%) and was significantly ($p \leq 0.05$) different from other tomato genotypes. However, the incidence of the viral disease started at 6WAT and got to the peak at 10WAT with Panther 17F1 recording the highest percentage incidence of virus disease at 10WAT (Fig. 1). However, 'Tiwantiwa' had no incidence of virus disease from nursery till the 9th week after transplanting. Infected 'Panther17F1' exhibited curled and twisted leaves and cessation of growth at the terminal ends which was common on other genotypes except "Agbara" The symptoms observed on 'Agbara' in which the symptoms observed were characterized by a pattern of light and dark green areas on the leaves and unambiguous mosaic foliar discoloration.

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Table 1: Seedling vigor and mean percentage virus disease incidence of eight tomato genotypes evaluated.

	SVG[a]	Weeks of observation for the percentage viral disease incidence				
		DI6WAT	DI 7WAT	DI 8WAT	DI 9WAT	DI 10WAT
FI COBRA26	14.60[a]	6.67[b]	6.67[ab]	16.34[d]	16.64 [c]	24.30[c]
F1 LINDO	12.36[bb]	8.88[a]	11.09[a]	18.19b [d]	42.30 [abc]	54.00 [abc]
ROMA SAV	10.18 [c]	0.00 [d]	6.67 [ab]	46.75 [ab]	36.30 [ab]	57.33 [ab]
AGBARA	9.07 [d]	6.67[b]	8.88a	42.32 [c]	52.30 [ab]	66.65 [ab]
BESKE	3.67e	6.67[b]	6.67 [ab]	48.66 [b]	55.98 [ab]	58.60 [ab]
PANTHER	13.04 [ab]	6.67[b]	11.09[a]	53.33[a]	68.89[a]	75.95[a]
HAUSA	3.45 [e]	4.45 [c]	8.88[a]	45.34 [bc]	49.92 [ab]	60.80 [ab]
TIWANTIWA	3.19 [e]	0.00 [d]	0.00[b]	0.00[e]	36.31[bc]	40.89 [bc]
Ms	0.76	32.79	37.67	1142.90	708.35	758.30
MsE	0.02	4.21	7.58	118.60	86.76	111.70

[a]SVG = seedling vigor, WAT= weeks after transplanting, DI = disease incidence

[b]values in columns followed by the same letter are not significantly different, P<0.05, Tukey's test.

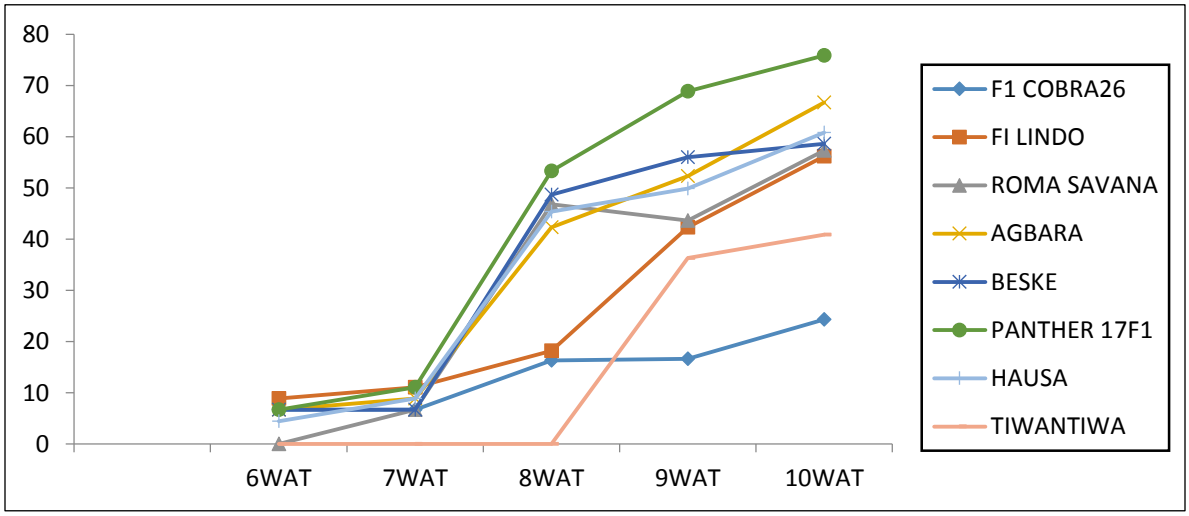

Figure 1: Virus disease incidence curve showing the eight tomato genotypes and their level of incidence at different weeks

Legend

WAT= Weeks after transplanting

Effect of viral disease incidence and growth parameters of the tomato genotypes

At 6 WAT, 'F1Cobra26' had the tallest plants (90.73 cm) and number of leaves and these were significantly ($p \leq 0.05$) different from other tomato genotypes (Tables 2a). At 9 WAT, 'Tiwantiwa' had the tallest plants and leaf production and these were significantly different from other tomato genotypes. However, there was no significant ($p \geq 0.05$) difference in the result obtained at 9 WAT and 10WAT (Table 2b).

Number of days to flowering and fruiting

'F1 Cobra 26' and 'Roma Savanna' were the earliest in attaining flowering and fruiting and were significantly ($p \leq 0.05$) different when compared with other tomato genotypes. However, there was no significant ($p \geq 0.05$) difference among other tomato genotypes (Table. 3)

Effects of viral disease incidence on yield attributes of the tomato genotypes

At 12 WAT, 'Panther 17F1' produced had the lowest yield which did not vary significantly ($p \geq 0.05$) from other tomato genotypes (Table. 4). Also 'Panther 17F1' and 'Agbara' had the lowest yield per hectare while there were no significant differences in the yield obtained among other tomato genotypes (Table 4). Disease incidence was directly associated with decreasing yield but it was not significant.

Table 2a: Mean plant height and number of leaves of eight tomato genotypes evaluated between 2 to 6 weeks after transplant.

Genotypes	Weeks of observation for plant height (cm) and number of leaves					
	PH 2WAT	PH 4WAT	PH6WAT	NL 2WAT	NL 4WAT	NL 6WAT
F1COBRA26	28.04a	57.30a	90.73a	72.00a	225.70a	303.23a
F1LINDO	22.63b	53.50ab	79.47ab	51.70ab	146.06b	242.00a
ROMA	16.50d	48.17ab	66.73bc	46.20ab	118.03bc	216.23a
AGBARA	17.83cd	29.15c	56.53c	33.35b	78.10c	191.16a
BESKE	19.67c	35.93bc	56.00c	50.57ab	161.06bc	374.00a
PANTHER	20.13bc	29.27c	54.90c	25.67b	82.90c	137.76a
HAUSA	18.50cd	36.50bc	59.87c	46.00ab	167.76b	345.67a
TIWANTIWA	19.73c	48.33ab	64.80bc	42.77b	148.56b	378.67a
Ms	563.02	359.24	490.88	562.81	6958.1	24311
MsE	88.08	42.08	28.12	88.11	358.1	10227

Mean in a column with the same letter(s) are not significantly different by Tukey (P=0.05)

Legend

PH = plant height
NL = number of leaves
WAT = weeks after transplanting

Table 2b: Mean plant height (cm) and number of leaves of eight tomato genotypes showing viral infection evaluated between 9 to 10 weeks.

Genotypes	Weeks of observation for plant height (cm) and number of leaves			
	PH 9WAT	PH 10WAT	NL 9WAT	NL 10WAT
F1COBRA26	68.17ab	68.17ab	249.67b	251.33b
F1LINDO	58.67bc	58.67bc	162.33c	162.33c
ROMA	56.50bcd	56.50bcd	80.00d	80.00d
AGBARA	56.67cd	56.67cd	88.67d	88.67d
BESKE	55.17cd	74.00a	202.33c	202.33c
PANTHER	44.00d	44.00d	112.00d	112.00d
HAUSA	55.00cd	45.67d	172.50c	172.50c
TIWANTIWA	76.83a	78.33a	352.00a	352.00a
Ms	311.76	24311	43663.0	46031.3
MsE	19.91	10227	259.1	260.6

Mean in a column with the same letter(s) are not significantly different by Tukey (P=0.05)

Legend: PH = plant height NL = number of leaves

Table 3: Mean number of days to fruiting of tomato genotypes.

Genotype	Number of days to maturity	
	ND to 50F[a]	ND to FR
F1COBRA26	68.00d[c]	72.33[e]
F1LINDO	72.33[a]	76.33 [cd]
ROMA	68.33[c]	78.67[b]
AGBARA	71.67[ab]	76.00 [cd]
BESKE	70.00 [b]	82.33[a]
PANTHER17F1	72.67[a]	76.00 [cd]
HAUSA	70.33[b]	75.33[d]
TIWANTIWA	71.33 [ab]	77.33[bc]
Ms	9.11	29.32
MsE	0.42	0.32

[a] ND to50F= number of days to 50% flowering; ND to FR = number of days to fruiting.
[b] values in columns followed by the same letter are not significantly different, P<0.05, Tukey's test.

Table 4: Means of yield components on tomato genotypes.

Genotype	Number of fruit produced per plant and yield·ha^{-1}				
	NFP/P10[a]	NFP/P12	Y/P10W(g)	Y/P12W(g)	Y/ha(tons)
F1COBRA26	1473[ab]	1307[a]	8410.70[a]	336.43 [a]	14.4 [a]
F1LINDO	1353[a]	923 [ab]	5618.33 [b]	224.73 [a]	9.64 [a]
ROMA SAV	1057[abc]	1023 [ab]	5085.50 [b]	203.42 [a]	8.73 [a]
AGBARA	671[b]	406[cd]	2857.60 [a]	114.3 [a]	4.9 [b]
BESKE	1256[ab]	1217[ab]	5672.58 [b]	226.9 [a]	9.73 [a]
PANTHER17F1	577[b]	277[d]	831.58 [c]	33.26 [b]	1.43 [b]
HAUSA	1533[ab]	537[bcd]	4785.25 [b]	191.41 [a]	8.2 [a]
TIWANTIWA	2517[a]	943[abcd]	7825.00 [a]	313.15 [a]	13.4 [a]
Ms	114.86	54	1813.6986	29.035	9.1
MsE	32.18	6.88	1189.0308	19.050	0.42

[a]. NFP/P/10 = number of fruit produced per plant at 10 weeks after transplanting, NFP/P/12 = number of fruit produced per plant at 12 weeks after transplanting, Y/P10W = yield per plant at 10weeks after transplanting, Y/P12W = yield per plant at 12 weeks after transplanting, Y/ha = yield·ha^{-1}.
[b] values in columns followed by the same letter are not significantly different, P<0.05, Tukey's test.

Table 5: Correlation coefficients between seedling vigour, disease incidence and yield

Characters	Seedling vigour.	Disease Incidence.
Disease Incidence.	-0.26	
Yield/ha	0.04	-0.49

Not significant at P ≥0.05

Table 6: Correlation coefficient between viral disease incidence and agronomic characteristics

Characters	Plant height(cm)	Number of leaves	Disease Incidence	No of Days to 50% Flowering	Number of Days to Fruiting	Number of fruits/plant	Yield
Plant height(cm)	1						
Number of leaves	0.20	1					
Disease Incidence	-0.57	-0.31	1				
No of Days to 50% Flowering	0.11	-0.04	0.40	1			
Number of days to Fruiting	-0.07	-0.16	0.45	0.86**	1		
Number of fruits/Plant	0.37	0.73*	-0.36	-0.14	-0.24	1	
Yield (g)	0.40	0.40	-0.36	-0.30	-0.46	0.78*	1

*significant @ P ≤0.05, **significant @ P≤ 0.01

Correlation between seedling vigor viral disease incidence and the fruit yield

High seedling vigour was directly associated with decreasing incidence of viral disease and increasing yield but both were not significant while percentage disease incidence was directly associated with decreasing yield but also not significant (Table 5).

Correlation between viral disease incidence and growth parameters

Table 6 shows the correlating coefficient in the relationship between growth parameters and viral disease incidence. The percentage increase in the incidence of viral disease was sufficiently correlated with the decreasing number of leaves ($p \leq 0.05$). Also, decrease in plant height was directly associated with increasing viral disease incidence but was not significant.

Discussion

The effect of viral infection was observed to be a major factor for consideration in assessing the general performance of the different tomato genotypes, as earlier suggested by Albert and Stephen, (2007). In this study, viral disease incidence was at its peak among the tomato genotypes at 10 WAT, probably due to the age of the plant and the onset of dry season in the study area which contributed significantly to the increase in the population of the virus vectors (white flies) at that time to suck the nectar of emerged flowers. Arogundade *et al.*, (2007) observed that as the population of the virus vectors rises the incidence of viral infection increases. The viral symptoms observed in 'BESKE', 'PANTHER17F1', 'HAUSA', 'ROMA SAVANNA', 'AGBARA' and 'TIWANTIWA' at 6 and 7 WAT could be attributed to the vectors carrying pathogens which aggravated the incidence of viral diseases as suggested by Arogundade *et al.*, (2007) and Lapidot *et al.*, (2002). 'F1 COBRA 26' and 'ROMA SAVANA' were the earliest in attaining flowering and fruiting and were significantly ($p \leq 0.05$) different from other tomato genotypes. These are early maturing and could be managed timely to meet the increasing demand for tomato. The yield obtained at 12 WAT generally reduced among all the genotypes especially for 'PANTHER17F1' and 'AGBARA. This could be as a result of the increasing trend and severity of the viral disease which led to abscission of the flowers that hindered the formation of fruit and development (Dias, 2011). The retardation in growth parameters generally observed on the tomato genotypes under infection; reduced number of leaves and plant height are indications of the effect of the occurrence of viral diseases on the tomato genotypes (Adebayo, 2005; Fajinmi et al., 2012). The yield reduction in 'PANTHER17F1' and 'AGBARA' could be as a result of the high level of viral disease incidence which hindered their normal growth and development. Disease has been reported as a limiting factor that hinders crops from achieving their genetic potentials (Brunt et al., 1995; Fajinmi, 2011; Fajinmi et al., 2012). However, it was observed that tomato ('TIWANTIWA' and 'F1COBRA26') with highest number of leaves produced relatively high yield, which could be attributed to high photosynthetic activities for food manufacturing compared with genotypes with reduced leaf production. Olson et al., (2005) observed that plants with high photosynthetic activities due to wider leaf coverage areas always produce more fruits than plants with limited leaf numbers and lower leaf surface area. 'TIWANTIWA' had no incidence of viral disease till the 8 WAT probably due to its high seedling vigour which contributed to its growth qualities and development of some adaptive features in resisting disease incidence at early stages. The better performance in terms of seedling vigour, lowered incidence of diseases, earliness to maturity. Higher yield observed in 'F1 Cobra 26' may be due to its genetic qualities. Besides, this may be due to the fact that late infections on the genotype caused less yield losses than those occurring early in plant development (Vidavski *et. al.,* 2008). The result showed that seedling vigour has direct relationship with reduction in the incidence of viral disease and increasing yield were not significant. This shows that genotypes with good seedling vigour had lower incidence of viral diseases and would produce high yields. This agrees with N'Diaga and Gebisa (2003) that there is a relationship in genetic variability and seedling vigour in the agronomic performance of sorghum.

The negative association between viral disease incidence and yield is similar to result observed by Fajinmi, (2012) and Fajinmi, (2013).

Conclusion and recommendation

Disease is an important limiting factor which hinders crops from achieving their inherent genetic potentials. The effects of the interaction of genotypes, seedling vigour and disease incidence on growth parameters and yield were different among the tomato genotypes that exhibited morphological variation.

Therefore, the results of the study have shown that viral disease incidence elicit various degrees of growth and yield of tomato but some tomato genotypes would still perform fairly well despite infection as a result of their genetic variability which impact some level of tolerance..

Since most tomato genotypes with good seedling vigour performed well with regards to growth ad yield attributes, it is therefore recommended to plant tomato genotypes such as; 'F1 COBRA 26' and 'TIWANTIWA' which performed well even under infection with viral diseases.

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