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Effects of Natural Virus Infection on Field-Grown Eight Tomato Genotypes (Lycopersicon esculentum)

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ABSTRACT

Tomato is the leading fruit vegetable in the world with over 177.04 metric tons of world production on a yearly basis but the production is generally more hindered by diseases than pests, as it is grown all through the world. This study evaluated the effects of natural virus infection on eight tomato genotypes, carried out at the Teaching and Research Farm of Federal University Oye-Ekiti. The eight tomato genotypes were arranged in a randomized complete block design with three replicates. Data collected were averaged and analyzed using Statistical Analysis System (SAS, 9.4) and significant means separated by the Tukey test. The results showed that a percentage increase in disease incidence among the genotypes was directly associated with decreasing yield but was not significant. Therefore, the viral disease incidence is associated with a reduction in the fruit yield of tomatoes but some tomato genotypes like; F1 COBRA26 and "TIWANTIWA" with high seedling vigor had significant fruit yield under natural virus infection on the field.

Keywords: Tomato genotypes, Field-grown, and natural viral infection.

INTRODUCTION

The tomato (*Lycopersicon esculentum)* is an annual plant that belongs to the family *Solanaceae*. With regard to its economic value, tomato constitutes 72% of the value of fresh vegetables produced worldwide (Ceponis *et al.,* 1979; Hanssen *et al*., 2010). Tomato is the leading fruit vegetable in the world with over 177.04 metric tons of world production on a yearly basis, the largest exporters of tomatoes are the Netherlands, Mexico, and Spain (www.worldatlas.com). The diseases of tomatoes are majorly classified as; fungal, bacterial, and viral causal agents. Many viral species that affect tomato crops have been reported (Hanssen *et al*., 2010). According to Brunt *et al.* (1995), the total number of viral diseases that infect tomato crops amounts to 136, for other vegetable crops, this number is notably low, only cucumber (*C. sativis*) has more viral pathogens (153) that surpasses that of tomato (Brunt *et al*., 1995). Most virus diseases cause stunting, leaf distortion, mosaic leaf discoloration, and spots or discoloration on fruit. Virus diseases are almost transmitted by insect vectors, most especially arthropods (sand flies and ticks), and the severity of a virus disease is usually tied to the rise and fall in the population of these vectors from season to season and within a given season. Tomato viral diseases are of different genera; tomato spotted wilt virus (tospovirus), tomato yellow wilt virus

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(begomovirus), and tomato mosaic virus (tobamovirus) are the most prominent in Nigeria (Arogundade *et al*., 2007). Tomato mosaic and tomato yellow virus diseases have been reported to be the most serious of all the virus diseases as they can cause as high as 20-90% loss in fruit yield (Arogundade *et al*., 2007). Tomato cultivation is generally more hindered by diseases than pests in most locations in Nigeria and the crop is considered as one of the major food groups and grown all through the world (Dias, 2011). Viral disease is an important limiting factor in many crop production systems and as a result of the unavailability of viral-resistant genotypes, has made the practice of good hygiene measures the only immediate control strategy in averting viral diseases, although these practices have only met limited success. In recent times, control strategies are now reliant on genetic resistance or hygienic measures to prevent viral diseases (Hanssen *et al*., 2010). Despite the immense contribution and efforts in human, animal, and plant health management, viral diseases remain notoriously difficult to control or eradicate owing to their large population size and short generation time, viruses have a great potential to quickly evolve, develop and adapt under natural selection pressure (Hanssen *et al*., 2010). The best control strategy for a viral disease is the introduction of genetic resistance in the plant host. However, the development of genetic resistance is time consuming and will, in most cases, become available only after the emerging virus has become well-established (Hanssen *et al*., 2010). Viral diseases are a major threat to sustainable and productive agriculture in the world, resulting in the yield reduction of crops (Mumford *et al.,* 2016). The report has also shown that different viruses exist in tomato, about 75.5% of the tomato plant population was reported to be infected by seven tomato viruses (Panno *et al*., 2012).

It has widely been reported that the genetic makeup of plants has a marked influence on seedling vigor (Qun *et al*., 2007; Savage and Bassel, 2015) and that seedling vigor in plants may be a veritable tool to tolerate viruses in the environment (pathosystem). Thus, there are differences in vigor, which exist among species, genotypes, and even within a variety of the same species. Therefore, considering the different tomato genotypes under investigation, there could be clear differences in their performance relating to seedling vigor, growth, and fruit yield characteristics that could reveal their tolerance to natural virus infections on the field. Hence, this justifies the need to establish in clear terms the responses of tomato genotypes to natural virus field infections and establish a correlation between natural virus infection, seedling vigor, and fruit yield.

MATERIALS AND METHODS

Experimental site

The experiment was conducted at the University Teaching and Research Farm, Federal University, Oye-Ekiti, Ikole Campus (7°48N; 05°29E) during the rainy season between August to November 2015 in two locations. The place is characterized by a tropical climate with 1500mm average rainfall per annum, 27^0c average temperature with high relative humidity in the rainy season that lasts for about eight months in a year. The land has long been subjected to the cultivation of arable crops such as maize, cassava, and cowpea. Total manual clearing of the experimental plot was done followed by minimum soil tillage of the plots.

Source of planting materials

Eight tomato genotypes were used for this experiment (4 hybrid and 4 local tomato genotypes). The hybrids were from Technisem, France but purchased at Green Gold Consult, Ikoyi, and Isaba in Ikole-Ekiti, Ekiti State, and 4 local tomato genotypes were gotten from the Ikole market after their seeds were extracted and processed. The hybrid tomato genotypes used were; F_1 Cobra 26, F_1 Lindo, Panther $17F_1$, and Roma Savanna. While the 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 of the tomato genotypes were raised in 5-liter round nursery bowls covered with an insect-proof net for a period of four weeks before they were transplanted to the field.

Experimental design and layout

The eight treatments were replicated three times on manually cleared land and laid out in a Randomized Complete Block Design (RCBD) with a total of forty-five (45) plants/genotypes. The experimental field was 15m by 8m (120m^2) and the site was manually cleared and the beds were made with hoes.

The experimental field was partitioned into 24 beds each representing a plot and replicated with a dimension of 2m by 1m and at a distance of 1m apart between each bed. The seedlings were transplanted to the raised beds at an inter-row spacing of 60cm and intra-row spacing of 50cm (60 by 50cm), with each plot/bed consisting of 15 stands per bed. All relevant cultural practices (staking, weeding, and watering) were carried out to maintain healthy plants.

Weed Management

Manual weeding was done to keep the experimental field weed-free until the end of the trial.

Data collection

Data was collected on the following parameters at different stages:

Nursery: Nursery was considered because seeding tomatoesthe directly into the field is not recommended due to the high cost of hybrid seed and the specific conditions required for adequate germination in South Western, Nigeria. The seedlings were transplanted at 4 weeks of age. In the nursery, the number of seedlings was physically counted from the first day of emergence to the last day of transplanting. The seedling vigor to estimated using the mathematical expression below;

$$Vigour = \frac{\text{number of normal seedlings (1st count)}}{\text{First count}} + \frac{\text{number of normal seedling (last count)}}{\text{Days to final count}}$$

Field: For the field experiment, five plants were randomly tagged per bed for data collection and records were averaged. The data included the following; Plant height (cm), determined by measuring the height from the soil surface to the apical shoot using a meter rule at weeks after transplanting, number of leaves, days to 50% flowering and fruiting, number of fruits produced per plant, yield per plant and yield per hectare.

Disease incidence (%) = This was determined by recording the number of plants showing unambiguous foliar characteristics of virus infection per bed. The viral disease incidence was estimated using the formula:

$$Disease\ incidence\ (\%) = \frac{\text{Number of infected plants/bed}}{\text{Number of plants/bed}} \text{ x } 100$$

Data analysis

Data were subjected to analysis of variance (ANOVA), through Statistical Analysis System (SAS) version 9.4 and means were separated using Tukey at a 5% level of significance. Correlation analysis was employed to estimate the degree of linear association between seedling vigour, disease incidence, and yield.

Results

Seedling vigor and percentage viral disease incidence of the tomato genotypes

Seedling vigor was highest for F_1 COBRA 26 (14.1) and was significant ($p \leq 0.05$) when compared to other tomato genotypes. AT 6 WAT (Weeks After Transplanting), ROMA SAVANNA, F_1 cobra 26, and "TIWANTIWA" had the least percentage incidence of virus disease (0%, 0%, and 6.67%) respectively. However, there was no significant ($p \leq 0.05$) difference in virus disease incidence among other tomato genotypes (Table 1). At 8 WAT, Panther17FI and "TIWANTIWA" were significantly ($P \leq 0.05$) different from other tomato genotypes with the highest and lowest percentage incidence of virus disease (53.33% and 0%) respectively (Table 1). At 10 WAT, F_1 COBRA26 and "TIWANTIWA" had the least incidence of virus disease (24.30% and 40.89%) respectively, and were both significantly ($P \leq 0.05$) different from other tomato genotypes (Table 1). PANTHER17F_1 had the highest virus disease incidence (75.95%) and was significantly

(P≤0.05) different from other tomato genotypes. However, the incidence of the viral disease started at 6WAT and reached the peak at 10WAT with Panther $17F_1$ recording the highest percentage incidence of virus disease at 10WAT. However, "TIWANTIWA" had no incidence of virus disease from nursery till the 9th week after transplanting. The symptoms on a PANTHER$17F_1$ showed curled and twisted leaves and cessation of growth at the terminal ends were mostly observed in all the tomato genotypes. While the symptoms observed on "AGBARA" were characterized by a pattern of light and dark green areas on the leaves and unambiguous mosaic foliar discoloration.

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

At 12 WAT, PANTHER $17F_1$ produced the lowest yield and yield did not vary significantly (p≤0.05) among other tomato genotypes (Table 2). Also PANTHER $17F_1$ and "AGBARA" had the lowest yield per hectare and there were no significant differences in the yield obtained among other tomato genotypes (Table 2). A decrease in the number of fruits per plant was directly associated with decreasing yield (Table 4). However, disease incidence was directly associated with decreasing yield but this was not significant (Table 4).

Correlation between seedling vigor, viral disease incidence, and fruit yield

High seedling vigor was associated with decreasing incidence of viral disease but was not significant (Table 3). Also, High seedling vigor was associated but not significant with increasing yield (Table 3). Percentage disease incidence was also associated but not significant with decreasing yield (Table 3).

Correlation between viral disease incidence and growth parameters

The percentage increase in the incidence of viral disease was directly associated with decreasing number of leaves (Table 4) and was significant at two levels (P≤0.05 and 0.01). Also, a decrease in plant height was associated but not significant with increasing viral disease incidence (Table 4).

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

At 6 WAT, F_1COBRA26 had the highest plant height and number of leaves and these were significantly (P≤0.05) different from other tomato genotypes (Table 5). At 9 WAT, "TIWANTIWA" had the highest plant height and leaf production and these were significantly different from other tomato genotypes. However, there was no significant (P≤0.05) difference in the result obtained at 9 WAT and 10 WAT.

Effect of Viral diseases incidence on selected growth parameters

F_1COBRA26 had the highest plant height (90.73cm) at maturity (PH6WAT) there was no significant (P≤0.05) difference among other tomato genotypes (Table 6). "TIWANTIWA" produced the highest number of leaves but there was no significant (P≤0.05) difference among other tomato genotypes.

Number of days to flowering and fruiting

The mean performance of the eight genotypes on flowering and fruiting were shown in Table 6. F_1 COBRA26 and ROMA SAVANA were the earliest in attaining flowering at 68 days. Fruiting was earliest set for F1 LINDO, PANTHER,$17F_1$, and HAUSA at 72 and 75 days respectively, and was significantly (P≤0.05) different from other tomato genotypes. However, there was no significant (P≤0.05) difference among other tomato genotypes.

Discussion

The effect of viral infection on the experimental plots is a factor to be considered in assessing the general performance of the different tomato genotypes. In this work, viral disease incidence got to the peak among the tomato genotypes at 10WAT, this could be due to the fact that it was approaching the onset of the dry season in the study area and whiteflies were abundant to suck the sap

of emerged plants, this agrees with the findings of Arogundade *et al*. (2007). The wilting symptoms observed in some of the genotypes like; "BESKE", PANTHER17F_1, "HAUSA", ROMA SAVANNA, "AGBARA" and "TIWANTIWA" at 6 WAT and 7WAT could be attributed to related disease-causing pathogens which aggravated the incidence of fungal diseases as this acquiesced with the previous studies of Lapidot *et al*. (2002) and Arogundade *et al*. (2007). F_1 COBRA26 and ROMA SAVANA were the earliest in attaining flowering and fruiting and were significantly ($P \leq 0.05$) different from other tomato genotypes. This implied that the two varieties are early maturing and could timely meet the increasing demand for tomatoes. Yield obtained at 12WAT generally reduced among all the genotypes, especially for PANTHER17F_1 and AGBARA. This was a result of the increasing trend of the viral infection which was more severe, and this led to the abscission of tomato flowers, hence reducing the number of fruits formed. This supported the finding of Dias (2011) that symptoms of viral diseases shown on naturally infected plants caused retardation in growth parameters such as; reduced number of leaves and plant height, this also reiterated the previous findings of Fajinmi *et al.* (2012) who found that viral infection causes delay in plant growth. The reduction in yield observed in PANTHER17F_1 and AGBARA could be as a result of the high level of viral disease incidence which hindered their normal growth and development. The disease has been reported as a limiting factor that hinders crops from achieving their genetic potential (Brunt *et al*., 1995; Fajinmi *et al.,* 2012). However, tomato genotypes with the highest number of leaves such as; "TIWANTIWA" and F_1COBRA26 produced relatively high yields, this could be attributed to high photosynthetic activities due to a high number of leaves used in the photosynthetic reactions for food manufacturing, compared to genotypes with a reduced leaf number. This corroborated the findings of Olson *et al*. (2005) who observed that plants with high photosynthetic activities with 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 8th week after transplanting; this may be due to its high seedling vigor which contributed to its growth qualities and development of some adaptive features in resisting disease incidence at an early stage. Better performance as seedling vigor, lower incidence of diseases, earliness to maturity and higher yield observed in F_1 COBRA26 may be due to its genetic qualities or this may also be due to the fact that late infections on the genotypes tend to cause less yield losses than those occurring early in plant development. Seedling vigor was directly associated with decreasing incidence of viral disease but was not significant and a positive association with increasing yield, which was also not significant. This indicated that genotypes with good seedling vigor had a lower incidence of viral diseases with high yields. This agrees with the view of Jones and Naidu (2019) who created a paradigm shift towards deploying integrated and eco-friendly strategies that are required to improve virus disease management. The negative association between viral disease incidence and fruit yield indicating that an increase in disease incidence was directly associated with decreasing yield but was not significant. This supports the finding of Ramyabharathi *et al*. (2012) who found that tomato yield has been reduced in India due to an increase in disease incidence.

Conclusion and recommendation

The disease is an important limiting factor that hinders crops from achieving their inherent genetic potential. Effects of genotypes, seedling vigor, disease incidence, and fruit yield on growth parameters showed significant differences within tomato genotypes. This ascertained that tomato genotypes respond differently to natural virus disease, which might be a major challenge faced by farmers in realizing the optimum yield potential of tomatoes in Africa. Natural viral disease infection reduces fruit yield under field conditions. It is therefore recommended to cultivate tomato genotypes with good seedling vigor such as F_1 COBRA26 and "TIWANTIWA" as they have the ability to perform well under natural virus field infection.

Table 1: Seedling vigour and mean percentage virus disease incidence of eight tomato genotypes

Genotypes	Weeks of observation for the percentage of viral disease incidence					
	SVG	DI 6WAT	DI 7WAT	DI 8WAT	DI 9WAT	DI 10WAT
F_1 COBRA26	14.60a	6.67b	6.67ab	16.34cd	16.64c	24.30c
F_1 LINDO	12.36b	8.88a	11.09a	18.19bcd	42.30abc	54.00abc
ROMA SAV	10.18c	0.00b	6.67ab	46.75abc	36.30ab	57.33ab
AGBARA	9.07d	6.67a	8.88a	42.32abc	52.30ab	66.65ab
BESKE	3.67bc	6.67a	6.67ab	48.66ab	55.98ab	58.60ab
PANTHER17F_1	13.04b	6.67a	11.09a	53.33a	68.89a	75.95a
HAUSA	3.45c	4.45ab	8.88a	45.34abc	49.92ab	60.80ab
TIWANTIWA	3.19d	0.00b	0.00b	0.00d	36.31bc	40.89bc
Ms	0.76	32.79	37.67	1142.9	708.35	758.3
MsE	0.02	4.21	7.58	118.6	86.76	111.7

Means with the same letter within each column are not significantly different (P<0.05)

Legend

SVG = seedling vigor

WAT = weeks after transplanting

DI= disease incidence

Table 2: Means of yield components on eight tomato genotypes

Genotypes	Number of fruits produced/plant and yield/ plant in grammes and yield/hectare				
	NFP/P10	NFP/P12	Y/P10W(g)	Y/P12W(g)	Y/ha(kg)
F_1 COBRA26	14.73ab	13.07a	8410.70a	336.43a	144,328a
F_1 LINDO	13.53a	9.23ab	5618.33a	224.73a	96, 410a
ROMA SAV	10.57abc	10.23ab	5085.50a	203.42a	87,267a
AGBARA	6.71b	4.06cd	2857.60a	114.3a	49,036b
BESKE	12.56ab	12.17ab	5672.58a	226.9a	97,341a
PANTHER17F_1	5.77b	2.77d	831.58b	33.26b	14,268b
HAUSA	15.33ab	5.37bcd	4785.25a	191.41a	82,114a
TIWANTIWA	25.17a	9.43abcd	7825.00a	313.15a	134,279a
Ms	114.86	54.00	18136986	29035	9.11
MsE	32.18	6.88	11890308	19050	0.42

The mean followed by the same letter within each column are not significantly different (P<0.05)

Legend

NFP/P/10 = number of fruits produced per plant at 10 weeks after transplanting

NFP/P/12 = number of fruits 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 per hectare

Table3: Correlation coefficients of seedling vigor, disease incidence and yield

Characters	Seedling v.	Disease I.
Disease I.	-0.26ns	
Yield/ha	0.04ns	-0.49ns

*significant @ P≤0.05; ns=not significant
Legend
Seedling v. = seedling vigor
Disease I. = disease incidence

Table 4: Correlation coefficients of seven agronomic characters observed in eight genotypes of tomato

Characters	Plant height(cm)	Number of leaves	Disease Incidence	No of Days to 50% Flowering	Number of Days to Fruiting	Number of fruits/ plant	
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*

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

Table 5: Mean plant height and number of leaves of eight tomato genotypes evaluated under infection

Genotypes	Weeks of observation for plant height (cm) and number of leaves					
	PHI 6WAT	PHI 9WAT	PHI 10WAT	NLI 6WAT	NLI 9WAT	NLI 10WAT
F_1COBRA26	63.67a	68.17ab	68.17ab	155.00a	249.67b	251.33b
F_1LINDO	50.33bc	58.67bc	58.67bc	116.00b	162.33c	162.33c
ROMA	0.00e	56.50bcd	56.50bcd	0.00d	80.00d	80.00d
AGBARA	0.00e	56.067cd	56.067cd	0.00d	88.67d	88.67d
BESKE	51.00b	55.17cd	55.17cd	76.67c	202.33c	202.33c
PANTHER17F_1	31.00d	44.00d	44.00d	56.00c	112.00d	112.00d
HAUSA	44.00c	55.00cd	55.00cd	68.33c	172.50c	172.50c
TIWANTIWA	0.00e	76.83a	78.33a	0.00d	352.00a	352.00a
Ms	2093.52	311.76	336.65	10008.2	43663.0	46031.3
MsE	5.58	19.91	19.91	116.1	259.1	260.6

Mean in a column with the same letter(s) are not significantly different (P=0.05)
Legend
DI = disease incidence
PHI = plant height of infected plants
NLI = number of leaves of infected plants

Table 6: Mean plant height, number of leaves, and days to fruiting of uninfected eight tomato genotypes evaluated

Genotypes	Weeks of observation for plant height (cm) and number of leaves						Number of days to maturity	
	PH2WAT	PH4WAT	PH6WAT	NL2WAT	NL4WAT	NL6WAT	NDto50F	NDtoFR
F_1COBRA26	28.04a	57.30a	90.73a	72.00a	225.70a	303.23a	68.00d	72.33e
F_1LINDO	22.63b	53.50ab	79.47ab	51.70ab	146.06b	242.00a	72.33a	76.33cd
ROMA	16.50d	48.17ab	66.73bc	46.20ab	118.03bc	216.23a	68.33cd	78.67b
AGBARA	17.83cd	29.15c	56.53c	33.35b	78.10c	191.16a	71.67ab	76.00cd
BESKE	19.67c	35.93bc	56.00c	50.57ab	161.06bc	374.00a	70.00bc	82.33a
PANTHER17F_1	20.13bc	29.27c	54.90c	25.67b	82.90c	137.76a	72.67a	76.00cd
HAUSA	18.50cd	36.50bc	59.87c	46.00ab	167.76b	345.67a	70.33b	75.33d
TIWANTIWA	19.73c	48.33ab	64.80bc	42.77b	148.56b	378.67a	71.33ab	77.33bc
Ms	563.02	359.24	490.88	562.81	6958.1	24311	9.11	29.32
MsE	88.08	42.08	28.12	88.11	358.1	10227	0.42	0.32

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

Legend
PH = plant height
NL = number of leaves
WAT = weeks after transplanting
NDto50F= number of days to 50% flowering
NDtoFR = number of days to fruiting

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آثار العدوى بالفيروسات الطبيعية على ثمانية انماط جينية من الطماطم المزروعة حقليا (Lycopersicon esculentum)

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تاريخ استلام البحث: 2022/7/6 وتاريخ قبوله: 2022/10/26.

ملخص

الطماطم هي خضروات الفاكهة الرائدة في العالم مع أكثر من 177.04 طنًا متريًا من الإنتاج العالمي على أساس سنوي، لكن الإنتاج بشكل عام يعاق من الأمراض أكثر من الآفات، حيث يتم زراعتها في جميع أنحاء العالم. قيمت هذه الدراسة آثار الإصابة بالفيروس الطبيعي على ثمانية انماط جينية من الطماطم، أجريت في مزرعة التدريس والبحوث التابعة للجامعة الفيدرالية Oye-Ekiti. تم ترتيب الأنماط الجينية الثمانية للطماطم في تصميم القطاعات الكاملة العشوائية بثلاثة مكررات. تم حساب متوسط البيانات التي تم جمعها وتحليلها باستخدام نظام التحليل الإحصائي (SAS، 9.4(والوسائل المهمة المفصولة عن طريق اختبار تركيا. أظهرت النتائج أن الزيادة المئوية في حدوث المرض بين الانماط الجينية ارتبطت بشكل مباشر بانخفاض المحصول ولكنها لم تكن معنوية. لذلك، يرتبط حدوث المرض الفيروسي بانخفاض محصول ثمار الطماطم ولكن لم يكن مهما إحصائيا، لكن بعض الأنماط الجينية للطماطم مثل، F1 COBRA26 و "TIWANTIWA" لها قوة شتلة عالية وغلة كبيرة من الفاكهة في ظل الإصابة بالفيروس الطبيعي في الحقل.

الكلمات الدالة: انماط الطماطم الجينية، الزراعة الحقلية، العدوى الفيروسية الطبيعية

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