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Food and Agricultural Organization (FAO), CABI and Scopus

**Journal of Agricultural Extension**  
Vol. 21 (2) June, 2017  
ISSN(e): 24086851; ISSN(Print); 1119944X  
<http://journal.aesonnigeria.org>  
<http://www.ajol.info/index.php/jae>  
Email: [editorinchief@aesonnigeria.org](mailto:editorinchief@aesonnigeria.org)

**Farmers Agronomic Practice in Management of the Tomato (*Solanum lycopersicon* L.)  
Yellow Leaf Curl Virus in Central Region of Ghana**

<https://dx.doi.org/10.4314/jae.v21i2.6>

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**Abstract**

*The study assessed farmers' awareness of tomato yellow leaf curl virus (TYLCV) disease and their agronomic and disease management practices in the Efutu municipality, Komenda-Edina-Eguafo-Abirem (KEEA), and Mfantseman districts which are leading tomato producing centres in the Central Region of Ghana. The study also surveyed the incidence and severity of the TYLCV disease in tomato fields across the three districts. Household data were collected using structured questionnaire from 150 respondents using multi-stage procedure, and analysed using descriptive statistics. Incidence (DI) and severity index (SI) of TYLCV disease were determined from forty (40) tomato fields selected from each of the three districts. The field data was subjected to analysis of variance (ANOVA) and the means separated with least significant difference (LSD) method at 5% level of probability. The majority of the farmers (92.6%) were aware of the TYLCV disease and said it could cause yield losses ranging from less than 10% to over 41% but did not know the cause. The majority (60.4%) of the farmers managed the TYLCV disease in their farms mainly by applying insecticides (55.6%) and rogueing of diseased plants (43.1%). About 61% of the farmers practiced mixed cropping, and most of them cultivated tomato in both the major and minor cropping seasons, using mainly an improved form of *Solanum pimpinellifolium*. The highest mean disease incidence and mean disease severity indices were recorded at KEEA (52.9±2.7%, 26.89±1.2%), followed by Efutu (49.5±1.19%, 25.29±0.9%), and Mfantseman (42.1±2.7%, 21.41±0.8%) respectively. In conclusion, TYLCV was highly prevalent in*

*the study area, but infection was moderate due to the use of improved tomato variety.*

**Keywords:** Tomato yellow leaf curl virus, disease incidence and severity, farmers' agronomic practices, disease management methods.

## Introduction

Tomato (*Solanum lycopersicon* L.), is the most popular and widely grown vegetable in the world. Production of tomatoes is a source of livelihood for young men and women in both the rural and urban centres in Ghana and worldwide (Tshiala and Olwoch, 2010). Among all vegetables in Ghana, tomato is normally used in large quantities and grown for fresh market and for processing (Norman, 1974). It is consumed nearly on a daily basis by every household in Ghana. Tomato is used as a fresh vegetable or as a spice in food preparation (Horna *et al.*, 2006; Olaniyi, 2010). It is used in soup, salad, gravy and stew (Horna *et al.*, 2006; Osei *et al.*, 2012). In terms of health, it contains large quantity of water, calcium, niacin and a good source of vitamins A, C and E which are of great importance in the metabolic activities of man (Olaniyi *et al.*, 2010).

In spite of the economic importance and health benefits of tomatoes, farmers in Ghana have been recording low yields. The current average yield of 7.5 t ha<sup>-1</sup> is far below the achievable yield of 15 t ha<sup>-1</sup> (MoFA, 2011). Consequently, local production does not meet the domestic demand, and so tomatoes are imported from Burkina Faso which affects the economy (MoFA, 2011; Osei *et al.*, 2012). This wide yield gap of tomato in Ghana is due to a number of constraints which include biotic and abiotic factors. The abiotic factors include erratic rainfall, high temperature, and poor soils, among others while the biotic factors include diseases such as *Tomato yellow leaf curl virus* (TYLCV), *Tomato mosaic virus* (TMV), bacterial wilt, bacterial spot and early blight (Asante *et al.*, 2013).

Among the diseases of tomato in Ghana, one which is of most economic importance is the TYLCV (Osei *et al.*, 2012). TYLCV is transmitted efficiently by the whitefly *Bemisia tabaci* (Gennadius) in a persistent circulating manner. Severe population outbreaks of the whitefly are usually associated with high incidence of the disease (Al-ani *et al.*, 2011). TYLCV can cause yield losses of up to 80% especially when plants are infected in the early stages of growth. The virus infection results in a decrease in leaf size, leaf curling upward, severe stunting and distortion linked with interveinal chlorosis. The plant becomes severely stunted, drops its flowers and stops producing marketable fruits when infection occurs at the early stages of growth (Al-ani *et al.*, 2011).

Effective management of the TYLCV disease is therefore quite important in order to improve yields. Information on the incidence and severity of the TYLCV disease will be an important pre-requisite for the development of appropriate and effective management strategies in order to improve the yield of tomato. Further, information on the tomato farmers' perception and knowledge levels of the TYLCV disease is also relevant in the development of such an effective management strategy. There is however limited information on the TYLCV disease in southern Ghana, as work done so far (Osei *et al.*, 2008; 2012) are concentrated at the middle and northern Ghana which are the major tomato producing centres of Ghana. However, tomato is also produced in commercial quantities in the Central region of Ghana. This study was conducted to assess the incidence and severity of TYLCV disease in farmers' tomato fields in the Central region of Ghana. The study also assessed farmers' perception and awareness of the TYLCV disease and their agronomic and disease management practices.

## Methodology

### Study Area

The study was conducted in three districts in central region of Ghana. The districts are Mfantseman district, Efutu Municipality and Komenda-Edina-Eguafo-Abirem (KEEA) district which are leading tomato producing areas in the Central region.

### Research Design

The study was a descriptive survey carried out in two phases. The first phase involved a household survey using questionnaire to identify farmers' perception and knowledge levels of the TYLCV disease and their agronomic and disease management practices that influence incidences of the disease in their tomato fields. The second phase involved a field survey to assess the incidence and severity of TYLV disease in farmers' tomato fields in the three districts.

### Household Survey

Questionnaire with both open-and closed-ended questions was administered to 50 tomato farmers purposively selected from each of the three districts from the Central region. In each of the three districts, five town communities were selected randomly and in each town community, ten households were selected using purposive and snowball sampling methods (Oliver, 2006). In total, 150 households were surveyed. The survey questionnaire was made up of four categories of questions which were based on (1) demographic characteristics of the farmers (2) farmers' agronomic practices (3) their knowledge of TYLCV disease and (4) their disease management practices. The questions were written in English and administered in both English and local languages (Akan).

### Assessment of Disease Incidence

Ten (10) tomato fields were selected from each of the 4 town communities from each of the three districts, and in each field, fifty tomato plants were randomly assessed for incidence and severity of TYLCV disease. These fields belonged to farmers who were earlier interviewed during the household survey (Table 1). The sizes of tomato fields surveyed ranged between half to two hectares. Incidence of TYLCV disease for the various fields was calculated according to Imran *et al.* (2012) as follows:

$$\text{Disease incidence} = \frac{\text{Number of infected plants}}{\text{Total number of plants}} \times 100 = \frac{\text{Number of infected plants}}{\text{Total number of plants}} \times 100$$

The severity of TYLCV disease in each field was assessed based on the 0-4 symptom severity scale developed by AVRDC (Lapidot and Friedman, 2002) as indicated in Table 2.

**Table 1: Visual scale for assessing the severity of Tomato yellow leaf curl virus disease**

Disease score	Description
0	No symptoms (healthy)
1	Slight yellowing (mild symptom)
2	Leaf curling and yellowing (moderate symptom)
3	Yellowing, curling and cupping (severe symptom)
4	Severe stunting, curling and cupping (very severe symptom)

The disease severity index was also calculated using the formula by Chomdej *et al.* (2007).

$$\text{Disease severity index} = \frac{\sum(\text{Rating scale} \times \text{Number of plants})}{\text{Total Number of Plants} \times \text{Highest Rating}} \times 100 = \frac{\sum(\text{Rating scale} \times \text{Number of plants})}{\text{Total Number of Plants} \times \text{Highest Rating}} \times 100$$

100

## **Data analysis**

Data from the household survey was analysed with descriptive statistics comprising means, frequency distributions and percentages, with Statistical Product and Service Solutions (SPSS) programme, version 16. Data on percentage incidence was arcsine transformed using angular in order to ensure homogeneity of the variance and normal distribution of the data. Data on disease severity score and the transformed disease incidence data were subjected to analysis of variance (ANOVA), and the means separated by least significant difference (LSD) method at 5% level of probability using GenStat Release version 12 (VSN International).

## **Results and Discussion**

### **Household Survey**

#### **Demographic Characteristics of Farmers**

The results from the household survey revealed that the majority (52.7%) of the total respondents were females as shown in Table 2. This result agrees with Asare-Bediako *et al.* (2014) who reported that more females were found in okra farming in Komenda-Edina-Egua-Abirem districts in the Central region than males. The high percentage of female farmers in the region was expected because tomato production unlike that of tree crops is non-laborious and hence can be engaged by both males and females. Besides, traditionally females are involved in vegetable production whereas males are involved in tree crops production. This is contrary to the report by Apantaku *et al.* (2016) which stated that farming in Kogi State of Nigeria is male dominated because farming in Nigeria is done manually by the rural farmers and require a lot of energy which may be too tedious for most women. Table 2 also indicates that the majority of the farmers were in the age range of 31 and 60. This result is in line with the report by Asare-Bediako *et al.* (2015) which stated that most pepper farmers in Ghana are in the age range of 30-59 years. This implies that most of the respondent farmers were within the productive age (Ibitoye, 2013; Apantaku *et al.*, 2016).

About 46.7% of the farmers had primary education, 7.3% had Junior High School Education/Middle School, 2% had Senior High School Education whereas most farmers (44%) had no formal education (Table 2). This agrees with the findings of Asare-Bediako *et al.* (2015). This suggests that the level of education of the respondents was low. The low educational level of most of the respondents could be a disadvantage in adopting improved agronomic practices such as roguing of diseased plants, destruction of crop residues and the elimination of alternative hosts (Lewis and Miller, 2004). Again, due to ignorance, farmers may undertake certain practices that may result in the spread of diseases (Asare-Bediako *et al.*, 2015). Most farmers (48.7%) had been in tomato production for more than 5 years, 44% of them had been in the production for between one and five years whereas 7.3% had been in tomato production for less than a year. This implies that the majority of the farmers have some experience in tomato production. It has been reported that farmers' experience in farming count more than educational attainment in order to increase productivity (Apantaku *et al.*, 2016) and this could influence their adoption of intensive and good agronomic practices such as early weeding, roguing, appropriate use of pesticides among others leading to low incidence of TYLCV disease in their farms. Nagaraju *et al.*, (2002) also stated that apart from the formal education being a source of information to farmers, experience in farming or number of years in farming can also serve as a means through which farmers get informed.

The majority of the farmers (52.6%) had small farm sizes that were less than 1 hectare (Table 2). About 34% had farm holdings which ranged between 1 and 2 hectares, whereas only 14% have farm holdings greater than 2 hectares. This conforms to the observation that the majority of the respondents in the region are smallholder farmers, and is consistent with the report of MoFA, (2011) which states that agriculture in Ghana is predominantly on a smallholder basis. Afari-Sefa *et al.* (2015) also reported that the majority of vegetable farmers in the Western and Ashanti regions of Ghana have small farm holdings, ranging from less than 0.4 ha up to 4 ha.

**Table 2: Household characteristics of farmers**

Variable	Percentage (n=150)
<b>Sex of the head of household</b>	
Female	52.7
Male	47.3
<b>Age of the head of household (years)</b>	
10-20	3.3
21-30	4.7
31- 40	20.0
41-50	39.3
51-60	18.7
61-71	14.0
<b>Level of education</b>	
No formal education	44
Primary	46.7
J.H.S	7.3
S.H.S	2
<b>Years in tomato production</b>	
< 1 year	7.3
1-5 years	48.7
>5 years	44.0
<b>Average land size (ha)</b>	
< 1	52.6
1 -2	33.6
> 2	14

### **Farm Characteristics and Agronomic Practices of Respondents**

Table 3 reveals that the majority (60.7%) of the farmers practiced mixed cropping while 39.3% practiced monocropping. This is at variance with the finding of Asare-Bediako *et al.* (2015) where the majority of the vegetable farmers in the Ashanti, Brong Ahafo, Volta and Central regions of Ghana practiced mixed cropping. The practice of mixed cropping could result in a reduction of spread of diseases in the tomato fields. Monocropping on the other hand is characterized by dense populations with genetic homogeneity and as a result, once a disease becomes established, it can rapidly spread to epidemic proportions (Arya, 2002;

Obeng-Ofori *et al.*, 2007). Most farmers (48%) cultivate tomato in both major and minor seasons, 42.7% practiced major season farming only whereas 9.3% engaged in minor season farming only (Table 4). Continuous cropping encourages disease build up in the fields leading to epidemics proportion as reported by Xiong *et al.* (2015); whereas either minor season or major season cropping only reduces disease outbreaks in crop fields .

Table 3 also shows that only few percentage of the farmers adopt good nursery practices in terms of application of starter solution (24.7%), covering the beds with a net to exclude whiteflies (7.3%), application of insecticides (19.3%) and burning of stubbles to sterilise the soil with heat (2.7% ). Most (46%) farmers only watered their seedlings without any other cultural practices. This poor nursery practices can influence the spread of the TYLCV disease in the farmers' fields.

The majority (74.3%) of the farmers used improved variety which consists of improved form of *S. pimpinellifolium* locally called "Fadzebegye tires" (44.3%) and exotic varieties (26%) as indicated in Table 3. Only 29.3% cultivate local cultivars. *S. pimpinellifolium* are known to carry a resistance gene against TYLCV (Lapidot and Friedmann, 2002). This is likely to reduce the spread and intensity of TYLCV disease in tomato fields in the study area.

**Table 3: Agronomic practices of tomato farmers**

Variable	Percentages (n=150)
<b>Cropping systems</b>	
Mixed cropping	60.7
Mono cropping	39.3
<b>Intercrops used</b>	
Pepper	42.8
Garden eggs	26.4
Cassava	18.7
Others (beans, sweet potatoes)	12.1
<b>Time of planting</b>	
Minor	9.3
Major	42.7
Both	48
<b>Nursery practices</b>	
Covering	7.3
Fertilizer (Starter solution)	24.7
Watering	46.0
Insecticide	19.3
Heat treatment	2.7
<b>Tomato varieties grown</b>	
Local	29.3
Improved (44.3% improved form of <i>Solanum pimpinellifolium</i> and 26% exotic varieties )	70.3

## **Farmers' Awareness of TYLCV Disease**

Table 4 shows that the majority (92.6%) of the farmers had knowledge about the TYLCV disease, whereas 18.7% of them had never observed the disease symptom. The high awareness of the TYLCV disease among the respondent farmers could partly be due to their experience in tomato production. It was observed that majority of the farmers have been in tomato production for over 5 years. This therefore agrees with the report of Nagaraju *et al.* (2002) which states that apart from formal education being a source of information to farmers, experience in farming or number of years in farming can also serve as a means through which farmers get informed.

Among the farmers who had experienced the disease in their farms, the majority (57.5%) did not know the cause while 42.5% claimed they knew the cause of the disease and attributed it mainly to unfavourable climatic conditions, soil nutrients deficiency, and whitefly infestation. This suggests that the farmers do not know the exact cause of the disease. This result agrees with the finding of Osei *et al.* (2012) which states that tomato farmers in the middle and northern Ghana wrongly attribute TYLCV disease to high temperature, nutrient deficiency, drought and whitefly (Osei, *et al.*, 2012). Nagaraju *et al.* (2002) also reported that majority of tomato farmers at Karnataka, India, were aware of TYLCV disease and could vividly describe the symptoms but did not know the causes and epidemiology of the viral disease. However, TYLV, transmitted by whitefly, *B. tabaci* has been associated with tomato yellow leaf curl symptoms on tomatoes in Ghana (Horna *et al.*, 2006; Osei *et al.*, 2008; 2012) and worldwide (Lapidot and Friedman 2002; Al-ani *et al.*, 2011; Pan *et al.*, 2012).

With respect to the growth stage at which farmers observed the symptoms of the disease in their farms, the majority of them (75.5%) said it was at the flowering stage; 13.7%, seedling stage, and 10.7%, the fruiting stage. This clearly indicates that the virus infects tomatoes at all growth stage. It has however been reported (Al-ani *et al.*, 2011) that when infection occurs at the early stages of growth, plants become severely stunted and stop producing marketable fruits leading to high yield losses.

Table 4 also reveals that the respondents were aware of the effect of the disease on tomato and could describe disease symptoms. The majority (57.6%) of the farmers indicated that the disease caused yield losses; 25.9% said the disease resulted in flower drop while 16.5% reported that the disease caused total death of plants. These symptoms are consistent with the symptoms of TYLCV disease described by Lapidot and Friedman (2002). This is also a clear indication that the disease is affecting tomato production in the study area. This finding thus agrees with Osei *et al.* (2012) who reported that TYLCV disease is a major biotic constraint to tomato production in Ghana. The respondents reported that the disease can cause yield losses ranging from less than 10% to over 40% (Table 4). This result corroborates the report of Glick *et al.* (2009) which states that TYLCV is so destructive that it can cause a yield loss as high as 100%.

**Table 4: Farmers' awareness of TYLCV disease**

Variable	Percentages (n=150)
<b>Are you aware of TYLCV disease?</b>	
Yes	92.6
No	7.3
<b>Are you aware of the causes of TYLCV disease?</b>	
Yes	42.5
No	57.5
<b>If yes, state the causes</b>	
Unfavourable climatic conditions	61.0
Soil deficiency	23.7
Whitefly	15.3
<b>At what growth stage do you see the symptoms of TYLC disease in your tomato farm?</b>	
Seedling	13.7
Flowering	75.5
Fruiting	10.7
<b>How does the TYLCV disease affect your tomato crop?</b>	
Death of plant	16.5
Yield loss	57.6
Flower drop	25.9
<b>State the yield effect of the TYLCV disease on the tomato</b>	
Less than 10%	6.5
Between 10-20%	12.9
Between 21-30%	14.4
Between 31-40%	17.3
Greater than 41%	48.9

### **Management of TYLCV Disease by the Respondent Tomato Farmers**

The majority (60.4%) of the farmers adopt various methods in the management of the disease on their farms (Table 5). About 55.6 % use pesticides, 43.1% practice rogueing of diseased plants, whereas 15.3% cover their tomato seedlings with mosquito nets at the nursery. This result could be due to the farmers' high awareness of the incidence of the TYLCV disease on their farms, and its effect on tomato crop. This finding agrees with Lewis & Miller (2004) who reported that basic knowledge about prevalence of a disease is one of the main tools in its management. Even though the majority of the farmers used insecticides to manage the TYLCV disease, some farmers considered the use of insecticide expensive and ineffective. The ineffectiveness of the insecticides could be due to the development of resistance against the insecticides by the whitefly vector. This is also suggestive that the farmers misuse or misapply the insecticide as reported by Ntow (2001). The ineffectiveness of the management methods employed by the farmers might have accounted for the failure of some farmers (39.6%) to manage the disease in their farms. It has been reported

(Never *et al.*, 2014) that farmers' adoption level depends on the claims and benefit of the innovation being introduced.

**Table 5: Management of TYLCV disease by the respondent tomato farmers**

Variable	Percentage
<b>Do you manage the TYLCD in your field?</b>	
Yes	60.4
No	39.6
<b>If no give reasons</b>	
High cost of insecticide	32.7
No effect after insecticide application	52.7
No reason	14.6
<b>If yes, state your management method *</b>	
Application of insecticides	55.6
Covering of seedlings at the nursery with nets	15.3
Removal of infected plant (rogueing)	43.1

\*Respondents gave multiple answers

### **Incidence and Severity of TYLCV Disease Determined from Farmers' Fields**

The TYLCV disease was prevalent in all the three districts surveyed (Table 6). The highest mean incidence was recorded in the KEEA district ( $52.9 \pm 2.7\%$ ), followed by Efutu municipal ( $49.5 \pm 1.2\%$ ) whereas Mfantseman district had the lowest ( $42.1 \pm 2.7\%$ ). The ANOVA showed significant differences in the incidences of TYLCV disease recorded in the three districts ( $F_{2,138} = 6.65$ ;  $P < 0.01$ ). Similarly, there was significant difference in the severity of TYLCV disease recorded at the various districts ( $F_{2, 138} = 6.83$ ;  $P < 0.01$ ) as shown in Table 6. The highest mean severity index was recorded at KEEA district ( $26.9 \pm 1.2\%$ ) which was not significantly different from that of Efutu municipal ( $25.3 \pm 0.9\%$ ) but significantly higher ( $P < 0.05$ ) than that of Mfantseman district ( $21.4 \pm 0.8\%$ ). This suggests that severities of TYLCV infection of tomatoes in the districts were low.

Differences in the cultural practices taking into account the type of insecticide, the time of application and covering of seedlings at the nursery could potentially affect the disease incidence and severity (Marley, 2004). Differences in the incidence and severity of the disease recorded in the study could also be attributable to possible variation in the strains of TYLCV virus present, with different levels of virulence. Three strains of TYLCV namely *Tomato yellow leaf curl Mali virus*, *Tomato yellow leaf curl Kumasi virus* and *Tomato yellow leaf curl Ghana virus* have been identified in tomato crops in Ghana (Osei *et al.*, 2012). The high prevalence of the TYLCV disease could also be due to the farmers' cropping patterns. It was observed that majority of the farmers practice monocropping in addition to both major and minor season cropping.

Even though TYLCV disease was prevalent in all the farms surveyed from the three districts in the Central Region, the mean disease severity in each farm or community was low. This

could at least partly be attributed to the fact that most of the respondents cultivate the improved varieties of *S. pimpinellifolium* locally called “Fadzebegye tires” which are known to carry a resistance gene against TYLCV (Lapidot and Friedmann, 2002). It could also be due to the possible infection of tomato plants by mild strains of TYLCV. Different strains of TYLCV have been reported to be infecting tomatoes at other parts of Ghana (Osei *et al.*, 2012) and these may have different levels of virulence. It is important to note that the study area falls within the coastal savannah zone of Ghana, whereas the work done so far on TYLCV disease were concentrated at the forest, Guinea savannah and the transition zone (Osei *et al.*, 2008; 2012). Thus different viral strains may occur in the different agro-ecological zones.

**Table 6: Mean incidences and severity of tomato yellow leaf curl virus disease on tomato fields in the Central Region**

District /Municipality	Mean incidence of TYLC disease (%)*	Mean severity index of TYLCV disease (%)*
Efutu	49.5 ±1.2 ab	25.3 ± 0.9 a
Mfantseman	42.1 ± 2.7 b	21.4± 0.8 b
KEEA	52.9 ± 2.7 a	26.9 ± 1.2 a
Mean	48.7 ± 1.4	24.53 ± 0.6
LSD ( $P<0.05$ )	8.8	3.0

Means in the same column bearing the different letters are significantly different ( $P\leq 0.05$ )

\*Mean ± Standard error

## Conclusion and Recommendations

The TYLCV disease was prevalent in the study area. However, the severities of infection were low. Farmers in the surveyed areas were aware of the symptoms of the disease but not the cause. The majority of the farmers planted an improved form of cherry-type tomato, *S. pimpinellifolium*, known to be resistant to TYLCV. In addition, they managed the disease by applying insecticides, roguing of diseased plants, and covering the seedlings at the nursery.

The Ministry of Food and Agriculture, through agricultural extension agents should educate farmers on good agronomic practices and appropriate use of insecticides in order to reduce spread of TYLCV disease in their tomato farms. Farmers should be educated on the use of improved variety of tomatoes, cover tomato seedlings at the nursery to exclude whitefly which vectors the TYLCV, and practice mixed cropping and clean farm sanitation in order to reduce disease epidemics.

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