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Spatio-Temporal Variations in the Incidence and Severity of Maize Streak Disease in the Volta Region of Ghana

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Abstract

The study was conducted to assess the influence of different agro-ecological zones and cropping seasons on the incidence and severity of maize streak disease (MSD) in Ghana. Field surveys were conducted in two districts each of the coastal savannah, forest, and transitional agro-ecological zones of the Volta region to assess the incidence and severity of MSD in farmers' fields, during the 2014 minor and 2015 major cropping seasons. The disease assessment was carried out in 12 fields from each district, and for each field on both maize plants growing under tree shade and in open parts of the field. The plants were scored for disease severity based on a 1-5 visual scale (1=no infection and 5=very severe infection). Percentage total N, available P, exchangeable K, organic matter levels and pH were determined from soil samples collected from each of the fields surveyed. Incidence and severity of MSD on maize plants growing under tree shade and in open parts of the fields were significantly higher (P<0.05) in the transition zone than in the forest and coastal savannah eco-zones during the 2014 and 2015 cropping seasons. Mean incidence and severity of MSD on maize plants growing under tree shade were significantly higher than those in the open part of the fields in both cropping seasons. The levels of MSD incidence and severity recorded in 2014 were significantly higher (P<0.05) than 2015. Low levels of soil total N, available P, exchangeable K and organic carbon were detected across the three agro-ecological zones. Incidence and severity scores of MSD were significantly and negatively correlated with soil total N, available P, exchangeable K and organic matter (P<0.01). In conclusion, MSD incidence and severity vary with the cropping seasons and agro-ecological zones and are partly affected by low soil fertility levels and tree shades.

Keywords: Maize Streak disease; Maize streak virus; Mastrevirus; Disease incidence and severity; Agro-ecological zones; Soil fertility

Introduction

Maize (*Zea mays* L.) is a principal food and cash crop for over 100 million people in Africa [1]. It is also a major constituent in livestock feed [2]. Maize is mainly produced by small-scale farmers in Ghana for food and income generation and as a source of livelihood.

Despite the economic importance of maize in Ghana, its current average yield of 1.7 metric tonnes per hectare is woefully below its potential yield of 6 metric tonnes per hectare [3]. This large yield gap is attributable to diversity of constraints, notably pests and diseases, low inherent yielding varieties, nitrogen and phosphorus deficiency [4,5] and drought [6] among others. Among the diseases, maize streak disease (MSD) caused by *Maize streak virus* (MSV; genus *Mastrevirus*, family Geminiviridae) is the most devastating and destructive disease of maize in Sub-Saharan Africa [7,8] including Ghana [9]. It is obligatorily transmitted by as many as six leafhopper species in the genus *Cicadulina*, (Homoptera: Cicadelidae) in a persistent manner [1] mainly by *C. mbila* Naudé and *C. storey* [10,11]. Incidence of MSD has been reported in several African countries including Ghana [9], Nigeria [12], Cameroon [13], Zimbabwe [14], Uganda [15], Kenya [7], Burundi [16] and South Africa (EPPO [17]) and on the islands of adjacent Indian Ocean (Reunion, Mauritius, Madagascar, Sao Tome and Principe) [17-23].

MSD can infect over 80 other plant species in the family Poaceae [24] including oats, wheat, sorghum, millet, finger millet and sugarcane [1,22]. MSD reportedly causes yield losses that range from a trace to almost 100% [25-27]. MSD is a major threat to cereal crops among smallholder farmers in Sub-Saharan Africa, causing up to 480 million USD losses annually [11].

Effective management of the MSD is required in order to improve yields of maize. Information on the prevalence and severity of MSD in Ghana is an important pre-requisite for developing an effective management strategy. However, such information is limiting in the country. The only available work [9] that assessed the prevalence of MSD in Ghana was limited to the minor season reports on the forest and transition zones of Brong-Ahafo, Ashanti, Eastern and Central regions, excluding the Volta region where the crop is a major staple. Soil fertility status has been found to influence the incidence of MSD and its vector *Cicadulina* spp. in Kenya [7] but such information is not available in Ghana. The aim of this study was to assess the incidence and severity of MSD on maize crops in the various agro-ecological zones of the Volta region and to determine their relationships with soil fertility levels of the maize fields surveyed. The results of this study will be very valuable in developing effective strategies for the management of the MSD.

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Materials and Methods

Field survey/disease assessment

A field survey was conducted in four maize fields from three communities in each of the six-major maize growing districts in the Volta region (3°45' latitude Nand 8°45' longitude N) during the minor (September-October, 2014) and major (July-August 2015) cropping seasons. Akatsi South and Ketu North districts were selected for the coastal savannah zone, Ho West and Kpandu districts for the forest zone (middle belt) and Krachi-East and Nkwanta South for the Forest-Guinea savannah transition zone (northern sector) Figure 1.

A transect (25 m^2) was made at three different points along the diagonal of each field and all plants within the transects were assessed for incidence and severity of MSD. The prevalence of MSD was determined by visually observing and recording the presence or absence of maize plants showing the disease symptoms. Disease incidence per field was estimated as the percentage of plants along the transects showing MSD symptoms [9]. The plants were also scored for disease severity based on a 1-5 visual scale [9,26] with a modification of 0.5 increments; where 1 represents no infection; 2, mild infection; 3, moderate infection; 4, severe infection and 5 very severe infection.

In each field disease assessment was done for maize plants growing under tree shade as well as in the open parts. The survey was undertaken when maize crops were between tasselling and physiological maturity, the period for optimum MSD development.

Collection of soil samples

Soil samples were collected from all the farms surveyed in order to determine the relationship between the concentrations of the major nutrients (total N, available P and exchangeable K) in soils from each maize field and disease incidence and severity. Surface soil samples (0 cm to 15 cm) collected from 20 different spots at each site were thoroughly mixed after all plant debris had been removed. The samples were air-dried and sieved through a 2 mm mesh sieve. The fine earth (<2 mm) fraction was used for laboratory analyses for total N, available P, exchangeable K, organic carbon and pH.

Soil analyses

Soil pH was measured potentiometrically using HM Digital pH meter (Greens Hydroponics, UK) in the supernatant suspension of soil to water ratio 1:2.5. Percentage organic carbon concentration was determined by the Walkley-Black method [28], while total nitrogen was determined using the micro Kjeldahl technique [29]. Available P was extracted by the Bray method and determined calorimetrically [30]. A soil extract was obtained with 1.0 M NH_4OAc (pH 7.0) and exchangeable K concentration in the extract was determined by flame photometry [31].

Data analyses

Data on disease incidence was arcsine transformed in order to homogenise the variance before being subjected to analyses of variance (ANOVA). The other quantitative data (severity scores of MSD, soil fertility status: N, P, K, organic C, pH) were also subjected to ANOVA and the means effect were separated by least significance difference (l.s.d) method at 5% level of probability. Pearson's correlation coefficients were calculated for the relationships between incidence and severity of MSD and soil total N (%), available P, exchangeable K, pH and organic matter. Comparisons of mean incidence and severity of MSD were made between maize plants growing under tree shades and those in the open parts of the fields across all the three agro-ecological zones using independent sample t-test. All statistical analyses were performed using GenStat Release version 9.2 Rothamsted Research International.

Results

Prevalence and severity of maize streak disease in the Volta Region

Mean incidence of MSD in the minor and major seasons: In the minor season, ANOVA indicated highly significant differences in the incidences of MSD in maize plants growing in the open parts of the fields (F=6.94; df =65; *P*=0.002) and under tree shades (F=6.46; df=65; *P*=0.003) among the ecological zones (Table 1). In respect of the plants growing in the open parts of the fields, the transition zone had significantly higher (*P*<0.05) mean incidence (73.5%) than the coastal savannah (69.3%) and forest zones (63.2%). Similarly, the transition zone had significantly higher (*P*<0.05) mean incidence (87.2%) than the coastal savannah (79.3%) and forest zones (79.1%), for maize plants growing under tree shade (Table 1). The ANOVA also showed that the overall mean incidence on maize plants growing under tree shade (81.87%) was significantly higher than those in the open parts of the fields (68.70%) during the minor season (F=80.81; df=125; *P*<0.001).

Similarly, in the major season, ANOVA indicated highly significant differences in the incidences of MSD in maize plants growing in the open parts of the fields (F=30.13; df=66; *P*<0.001) and those growing under tree shades (F=31.03; df=65; *P*<0.001) among the ecological zones (Table 1). Mean disease incidence recorded for the transition zone (31.7%) was not significantly different (*P*>0.05) from that of the forest zone (27.9%) but significantly higher than that of the coastal savannah zone (24.3%), with respect to maize plants growing in the open parts of the fields. Also, among maize plants growing under tree shades, the mean incidence recorded for the transition zone (50.4%)

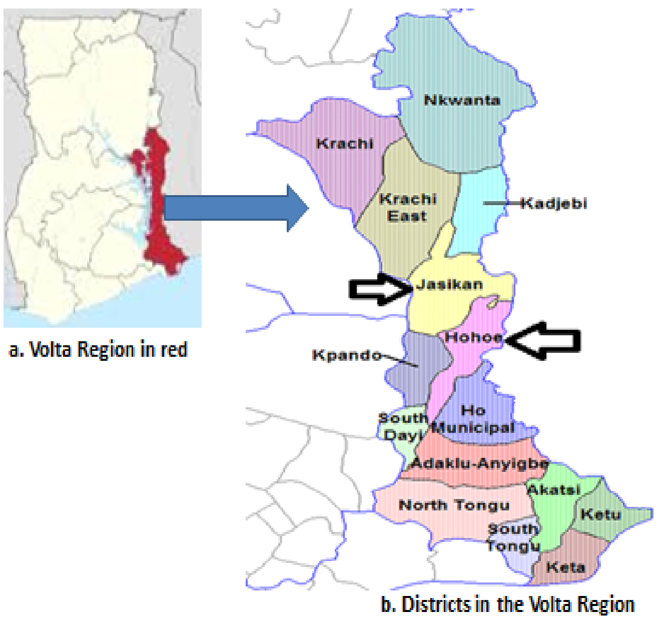

Figure 1: Map of Ghana showing: a. Volta Region in red and b. Districts in the Volta region.

was not significantly different (P>0.05) from that of the forest (44.1%) but significantly higher than that of the coastal savannah (36.3%) zones (Table 1). The ANOVA also revealed that the overall mean incidence on maize plants growing under tree shades (43.6%) was significantly higher (F=46.15; df=125; *P*<0.001) than those in the open parts of the fields (27.97%) during the major season.

l.s.d. for comparing overall mean incidence difference between open and shade=2.9 at 125 df (minor season). F=80.81; df=125; *P*<0.001.

l.s.d. for comparing overall mean incidence difference between open and shade=3.788 at 125 df (minor season); F-value=46.15; *P*<0.001.

Data on disease incidence was arcsine-transformed before ANOVA was done.

Mean severity scores of MSD in the minor and major cropping seasons: The mean severity scores of MSD recorded at the various agro-ecological zones in the minor season differed significantly amongst them for maize plants growing in the open parts of the fields (F=11.46; df=55; *P*<0.001) and those under tree shades (F=8.32; df=55; *P*<0.001) as shown in Table 2. For maize plants growing in the open parts of the fields, the transition zone had significantly higher (*P*<0.05) mean severity score (3.093) than the forest (2.570) and the coastal savannah zones (2.724). Similarly, the transition zone had significantly higher (*P*<0.05) mean severity score (4.241) than the forest (3.639) and the coastal savannah zones (3.782) among the maize plants growing under tree shades. The overall mean severity score of MSD on maize plants growing under tree shades (3.888) was significantly higher (F=217.76; df=126; *P*<0.001) than those growing in open parts of the fields (2.796) as indicated in Table 2.

In the major season, ANOVA revealed highly significant differences in the severity of MSD in maize plants growing in the open parts of the fields (F=16.75; df=57; *P*<0.001) and those growing under tree shades (F=17.96; df=57; *P*<0.001) among the agro-ecological zones (Table 2). In respect of maize plants growing in the open parts of the fields, the mean severity scores recorded for the transition zone (1.458) was not significantly different from that of the forest zone (1.398) but significantly higher (*P*<0.05) than the coastal savannah zone (1.134). Among plants growing under tree shades, the transition zone had significantly higher mean severity score (2.199) than the forest (1.816) and coastal savannah zones (1.402) (Table 2).

The overall mean severity score of MSD on maize plants growing under tree shades (1.806) was significantly higher (F=60.55; df=126; *P*<0.001) than those growing in open parts of the fields (1.330) during the major season (Table 2).

l.s.d. for comparing overall mean severity scores between open and shade=0.1464 at df of 126 (minor season); F-value=217.76; df=126; *P*<0.001.

l.s.d. for comparing overall mean severity scores between open and shade=0.216 at df of 126 (major season); F=60.55; df=126; *P*<0.001.

Seasonal comparisons of incidences and severities of MSD: An independent sample t-test analyses revealed that the mean incidence of MSD recorded in the minor season was significantly higher than those in the major season for maize plants growing in the open parts of the fields (t=27.23; df=69; *P*<0.001) and those under tree shades (t=17.84; df=125; *P*<0.001) as indicated in Table 3. Similarly, the MSD severity scores recorded in the minor season was significantly higher than the major season for maize plants growing in the open parts of the fields (t=26.67; df=70; *P*<0.001) and those under tree shades (t=21.24; df=54; *P*<0.001) (Table 3).

Relationships between incidence and severity of maize streak disease: Mean incidence of MSD recorded in the minor season was positively and significantly correlated with mean disease severity score in respect of maize plants growing in the open parts of the fields (r=0.5839; *P*<0.0001) and those growing under tree shades (r=0.4837; *P*<0.0001) as shown in Figures 2 and 3, respectively. Similarly, there were positive and significant correlations between mean MSD incidence and mean severity scores recorded in the major season for maize plants growing in the open parts of the fields (r=0.7969; *P*<0.0001) and those under tree shades (r=0.8468; *P*<0.0001) as indicated in Figures 4 and 5, respectively.

Influence of soil fertility on the incidence and severity of MSD: Soil pH, total N (%), available P (μ.gg^{-1}) and exchangeable K (cmol kg^{-1}) concentrations in the soils surveyed are shown in Table 4. The percentage total N concentrations in the soils were found to vary significantly among the agro-ecological zones (F=6.28; df=55; *P*=0.003). The total N concentrations in the transition zone (0.1%) was not significantly different from the forest zone (0.08%) but significantly higher than the coastal savannah zone (0.05%). There were no significant differences

Agro-ecological zone	Mean MSD incidence (%) in the minor season*		Mean MSD incidence (%) in the major season	
	Open	Shade	Open	Shade
Coastal savannah	69.4 b	79.1 b	24.3 b	36.3 b
Forest zones	63.2 c	79.3 b	27.9ab	44.1 a
Transition	73.5 a	87.2 a	31.7 a	50.4 a
Mean	68.70b	81.87a	27.97b	43.60a
I.S.D (*P*<0.05)	5.53	4.96	4.301	6.29
Means in the same column bearing the same letters are not significantly different from each other (*P*<0.05). * Mean ± S.D				

Table 1: Mean incidence of maize streak disease across the three agro-ecological zones of the Volta region of Ghana during 2014 minor and 2015 major cropping seasons.

Agro-ecological zone	Disease severity in the minor season		Disease severity in the major season	
	Open	Shade	Open	Shade
Coastal savannah	2.724^b	3.782^b	1.134^b	1.402^c
Forest zones	2.570^b	3.639^b	1.398^a	1.816^b
Forest-Guinea savannah transition	3.093^a	4.241^a	1.458^a	2.199^a
Mean	2.796^b	3.888^a	1.330^b	1.806^a
I.s.d. (*P*<0.05)	0.2250	0.3095	0.1131	0.2708
Means in the same column bearing the same letters are not significantly different from each other (*P*<0.05)				

Table 2: Mean maize streak disease severity scores recorded at the three ecological zones in the Volta region during 2014 minor and 2015 major cropping seasons.

Variables*	df**	t-test	*P*-value
MSD incidence in the open fields between 2014 and 2015	69	27.23	<0.001
MSD incidence under tree shade between 2014 and 2015	125	17.84	<0.001
MSD severity in the open fields between 2014 and 2015	70	26.67	<0.001
MSD severity under tree shade between 2014 and 2015	54	21.24	<0.001
*Means for comparison are indicated in Tables 1 and; **df=Degree of freedom			

Table 3: Independent samplet-test comparisons of mean incidence and severity of maize streak disease (MSD) between 2014 (minor crop season) and 2015 (major crop season).

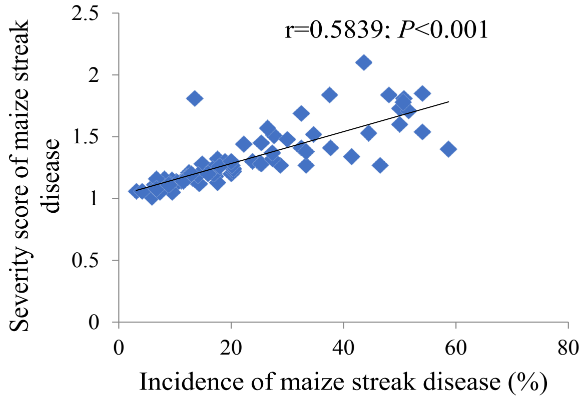

Figure 2: Relationship between incidence (%) and severity scores of maize streak disease on maize plants growing in the open parts of maize fields during the rainy season.

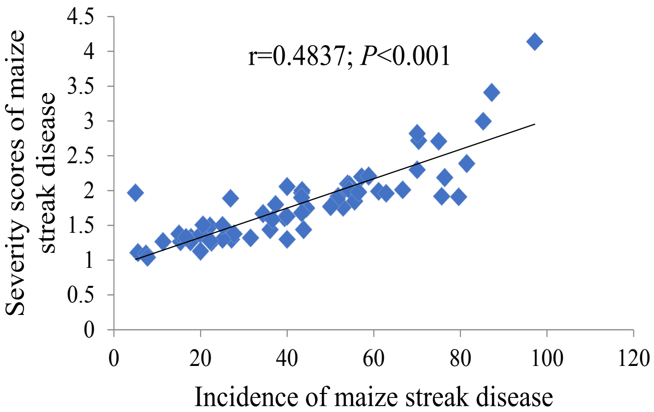

Figure 3: Relationship between incidence (%) and severity scores of maize streak disease on maize plants growing under tree shade during the rainy season.

among the agro-ecological zones with respect to available P (F=2.14; df=55; *P*=1.00) and exchangeable K (F=0.127; df=55; *P*=0.375) levels in the soils, even though the transition zone had the highest levels and the coastal savannah the lowest. The agro-ecological zones differed significantly in respect of the soil organic matter content (F=6.57; df=55; *P*=0.03). The mean soil organic matter content of the forest zone (2%) was not significantly different from the transition zone (1.55%) but significantly higher than the coastal savannah (0.99%). Interestingly, the mean soil pH in all the agro-ecological zones was the same (pH 6), indicating slightly acidic soils.

Correlation between soil fertility status and incidence and severity of maize streak disease: Incidence of MSD was significantly and negatively correlated with soil exchangeable K (r=-0.841; *P*<0.001), percentage total N (r=-0.838; *P*<0.001), available P (r=-0.775; *P*<0.001), soil organic carbon (r=-0.828; *P*<0.001) and soil pH (r=-0.997; *P*<0.001) as shown in Table 5. Similarly, there were significant and negative correlations between mean MSD severity scores and soil exchangeable K (r=-0.790; *P*<0.001), percentage total N (r=-0.833; *P*<0.001), available P (r=-0.773; *P*<0.001), organic carbon (r=-0.822; *P*<0.001) and soil pH (r=-0.997; *P*<0.001) indicated in Table 5.

[a]Data represent MSD incidence and severity scores determined in open parts of the maize fields during the 2014 minor cropping season when the soil sampling was done.

Varieties of maize cultivated by the farmers: In both the minor and major cropping seasons, the maize plants that were surveyed were of both improved and local varieties, with the improved varieties being predominant (Table 6). Comparatively, the transition zone had the highest percentage of improved variety (63.6% to 100%), followed by the forest zone (66.7% to 75%) whereas the coastal savannah had the lowest (50% to 58%).

Discussion

The study has revealed high prevalence of MSD across the three agro-ecological zones in the Volta region, with overall mean incidences of 68.70% and 81.87% for maize growing in the open parts of fields and those under tree shades, respectively, in the minor season, and overall mean incidences of 24.3% and 31.7% for maize growing in the open parts of fields and those under tree shades, respectively, in the major season (Table 2).These findings are comparable to that of Rose [19] and Oppong et al. [9]. Mean MSD prevalence of 18.44% was reported by Oppong et al. [9] when they conducted a survey of MSD in maize crops in the forest and transition zones of Brong-Ahafo, Ashanti, Eastern

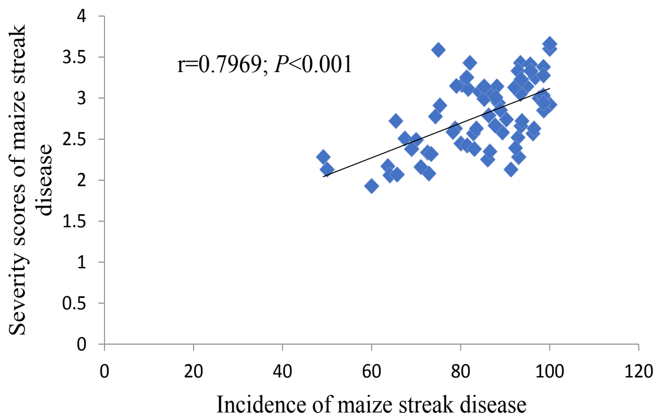

Figure 4: Relationship between incidence (%) and severity scores of maize streaks disease on maize plants growing in open parts of maize fields during the dry season.

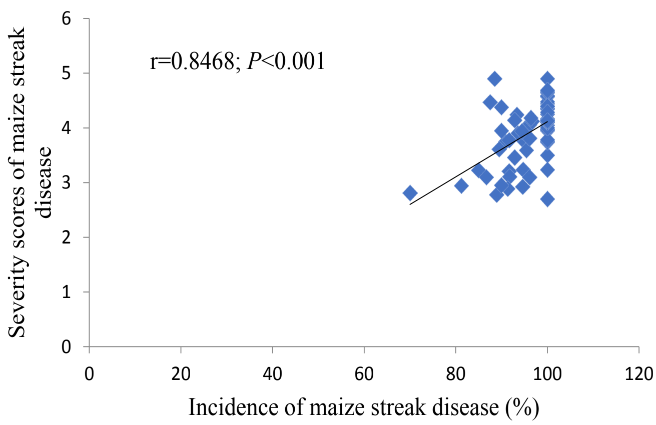

Figure 5: Relationship between incidence (%) and severity scores of maize streaks disease on maize plants growing under tree shade during the dry season.

Ecological zone	Total N (%)	Available P (μgg^{-1})	Exchangeable K (cmolkg^{-1})	Organic matter	pH
Coastal savannah	0.05[b]	9.55	0.45	0.99	6.6
Forest	0.08[a]	13.32	0.40	1.67	6.6
Transition	0.10a	16.14	0.56	2.00	6.6
Mean	0.08	13.00	0.47	1.55	6.6
l.s.d	0.028	2.139	-	0.568	-
P-value	0.003	0.127	0.375	0.003	0.970

Table 4: Soil pH, total N (%), available P (μgg^{-1}) and exchangeable K concentration (cmol kg^{-1}) in the soils surveyed.

Variable[a]	Total N (%)	Available P	Exchangeable K	Organic matter	pH
Mean MSD incidence	-0.838**	-0.775**	-0.841**	-0.828**	-0.997**
Mean MSD severity score	-0.833**	-0.773**	-0.790**	-0.822**	-0.997**
**Highly significant (*P*<0.001)					

Table 5: Pearson's correlation coefficients between mean maize streak disease (MSD) incidence and severity scores and soil fertility status.

and Central regions of Ghana in the minor season. This suggests that MSD is widespread in all maize growing areas in Ghana and the higher levels of incidence and severity observed in our study suggest that there is an epidemic of MSD in the Volta region. This could have serious consequences on maize production among the smallholder farmers in the Volta region. Yield losses of up to 100% due to MSD have been reported in many countries in West Africa [25,27]. It has however been argued [24] that even in epidemic years, disease incidences can vary from a few infected plants per field, with little associated yield loss, to 100% infection with complete yield loss.

Higher levels of incidence and severity of MSD were consistently recorded in the transition eco-zone of the Volta region than the forest and coastal savannah eco-zones during both minor and major cropping seasons. This could be due to differences in environmental conditions and varying virulence of MSV strains occurring at various agro-ecological zones. Important differences in the virulence of different MSV-A subtypes in maize have been reported [32]. Subtypes A1, A2 and A5 isolates produce the severest symptoms, subtypes A3 and A6 isolates produce intermediate symptoms, while subtype A4 isolate produce the mildest symptoms. Possibly, the strain of MSV-A infecting maize at the transition zone was more virulent than that of the forest and coastal savannah, hence the more severe symptoms at the transition zone than the forest and the coastal savannah zones. It has also been reported [1,32] that virulent MSV isolates cause earlier symptoms with wider and more chlorotic streaks than the mild isolates. This could explain why higher levels of incidence and severity of MSD were recorded at the transition zone than the forest and the coastal savannah zones.

Differences in the climatic conditions prevailing at the different agro-ecological zones could affect the leafhopper populations. Bosque-Perez and Buddenhagen [33] observed that the humid forest locations in the southern part of Nigeria often have consistently low leafhopper populations during most of the year compared to the dry northern locations. It is also reported [33] that generally, MSD incidences are associated with leafhopper density in the rain forest and northern Guinea Savanna zones but not in the southern Guinea Savanna zone of Nigeria.

Incidence and severity of MSD were found to be higher in maize plants growing under tree shades than those in the open parts of maize fields. This finding is consistent with that of Kyetere and William [26] who reported that incidence of MSD is greater in the shade than in the open parts of the field due to vector preference for shade. Thus, the higher the vector density under tree shade, the higher the disease incidence [34]. It has therefore been suggested that incidence and severity of MSD could be controlled by cultural practices [7]. Weeding and pruning of trees and planting maize in an open area where there are no trees can reduce vector population and the disease, as *Cicadulina* species prefer shade [35].

In addition to ecological zone and shading effect, incidence of MSD has been found to vary according to planting date and variety [36,37]. In our present study higher levels of incidence and severity of MSD were recorded in the minor rainy season (late planting) than in the major rainy season (early planting) (Table 3). This is consistent with the finding of Fajemisin et al. [38] who reported that late season plantings (July to October) suffer higher disease incidence than early season ones (March to May). This could be due to higher density of leafhoppers in the minor season than in the major rainy season, which may be partly due to an increase in insect mortality due to excessive impact of heavy rain drops in the major season than the minor cropping season [33]. It has also been reported [24] that MSD epidemiology is primarily governed by environmental influences on its vector species, resulting in erratic epidemics every 3-10 years.

Farmers in the region also plant different varieties of maize, both local and improved (Table 6), with varying reactions to MSV. This could also influence the levels of incidence and severity of the MSD reported in the study. Improved maize varieties such as Obatanpa, et al. are reported to be resistant to MSV [39,40] compared to the local varieties.

The results of the soil analyses indicated that the soils surveyed were slightly acidic (pH 6.0) and had low inherent nutrients content (total N<0.13%; available P<0.20 μg g^{-1}; ECEC<5 c mol kg^{-1}) as reported by Yeboah et al. [41]. The significantly higher organic matter content at the forest and transition zones compared to the coastal savannah zones could be attributable to the high vegetative cover in the forest and transition zones which could add more litter to the soil. Nonetheless, the levels of soil organic matter in all the agro-ecological zones were low. The low soil organic carbon content could be due to rapid decomposition of organic matter promoted by the prevailing high temperatures and high humidity [42], and continuous cropping without the return of crop residues to replenish the soil organic C stock [43]. The slightly low soil pH may be attributed to continuous cropping and leaching of soil basic cations [44].

The high prevalence and severity of MSD observed at various ecological zones could be partly due to low soil fertility status and this is supported by the significantly negative correlation between disease incidence, severity and soil nutrients (Table 6). This corroborates findings of Magenya et al. [7] who noted that soil nutrient levels

Ecozone	Cropping Season	% Local variety	% Improved variety	Improved varieties surveyed
Coastal savannah	Minor	50	50	Obatanpa, Etubi, Toxpeno, PAN 53
	Major	42	58	Obatanpa, PAN 53
Forest	Minor	25	75	Obatanpa, Etubi, Akposoe, Okomasa
	Major	33.3	66.7	Obatanpa, Dorke
Transition	Minor	36.4	63.6	Obatanpa, PAN 53
	Major	0	100	Obatanpa, PAN 53, Dorke

Table 6: Maize genotypes cultivated by the farmers.

influence MSV vector (*Cicadulina* spp.), which correlates positively with MSV disease incidence. Potassium (K) fertilizer is widely reported to decrease insect infestation and disease incidence in many host plants [45], as K promotes the development of thicker outer walls in epidermal cells, thus preventing attack by insect vectors [46]. In his literature review, Perrenoud [47] found that the use of K significantly decreases the incidence of virus diseases by 41%.

Conclusions

There is high prevalence of MSD across the three agro-ecological zones of the Volta region. Incidence and severity of MSD were consistently higher in the transition eco-zone than the forest and coastal savannah eco-zones during both minor and major cropping seasons. The incidence and severity of MSD were higher in the minor season than the major season. The soils of the maize fields surveyed were slightly acidic (pH 6.0) and had low inherent nutrient content (N, P, K, organic C). There were significant negative correlations between disease incidence and severity and soil nutrient content (N, P, K, organic C).

References

1. Bosque-Pérez NA (2000) Eight decades of maize streak virus research. Virus Res 71: 107-121.
2. Romney DL, Thorne P, Lukuyu B, Thornton PK (2003) Maize as food and feed in intensive smallholder systems: management options for improved integration in mixed farming systems of east and southern Africa. Field Crop Res 84: 159-168.
3. Amanor-Boadu V (2012) Maize price trends in Ghana (2007-2011). Monitoring, evaluation and technical support services (METSS) USAID, 2012.
4. Nziguheba G, Merckx R, Palm CA (2002) Soil phosphorus dynamics and maize response to different rates of phosphorus fertilizer applied to an Acrisol in western Kenya. Plant and Soil 243: 1-10.
5. Whitbread AM, Jiri O, Maasdorp B (2004) The effect of managing improved fallows of Mucunapruriens on maize production and soil carbon and nitrogen dynamics in sub-humid Zimbabwe. Nutrient Cycling in Agroecosystems 69(1): 59-71.
6. Kamara AY, Menkir A, Badu-Apraku B, Ibikunle O (2003) The influence of drought stress on growth, yield and yield components of selected maize genotypes. J Agr Sci 141: 43-50.
7. Magenya OE, Mueke J, Omwega C (2008) Significance and transmission of maize streak virus disease in Africa and options for management: A review. Afri J Biotech 7: 4897-4910.
8. Martin DP, Shepherd DN (2009) The epidemiology, economic impact and control of maize streak disease. Food Security 1(3): 305-15.
9. Oppong A, Bedoya CA, Ewool MB, Asante MD, Thomson RN (2014) Bulk genetic characterization of Ghanaian maize landraces using microsatellite markers. Maydica 59: 1-8.
10. Storey HH (1925) The transmission of streak virus of maize by the leafhopper Balclutha imbila Naude. Ann Appl Biol 112: 422-39.
11. Karavina C (2014) Maize streak virus: A review of pathogen occurrence, biology and management options for small holder farmers. Afr J Agric Res 9: 2736-2742.
12. Oluwafemi S, Kraberger S, Shepherd DN, Martin DP, Varsani A (2014) A high degree of African streak virus diversity within Nigerian maize fields includes a new mastrevirus from Axonopus compressus. Arch Virol 159: 2765-2770.
13. Leke WN, Njualem DK, Nchinda VP, Ngoko Z, Zok S, et al. (2009) Molecular identification of Maize streak virus reveals the first evidence for a subtype A1 isolate infecting maize in Cameroon. Plant Pathol 58: 782.
14. Mawere S, Vincent V, De Meyer J, Pixley KV (2006) Resistance of four inbred maize lines to inoculation with 20 isolates of maize streak virus from Zimbabwe. Plant D 90: 1485-1489.
15. Owor BE, Martin DP, Shepherd DN, Edema R, Monjane AL, et al. (2007) Genetic analysis of maize streak virus isolates from Uganda reveals widespread distribution of a recombinant variant. J Gen Virol 88: 3154-3165.
16. Zeigler R, Gashaka W, Kaybigi M (1985) Maize streak disease in Burundi highlands. Tropicultura 3: 130-34.
17. Brunel S, Panetta D, Fried G, Kriticos D, Prasad R, et al. (2014) Preventing a new invasive alien plant from entering and spreading in the Euro-Mediterranean region: the case study of Parthenium hysterophorus. EPPO Bulletin 44: 479-89.
18. Bock KR, Guthrie EJ, Woods RD (1974) Purification of maize streak virus and its relationship to viruses associated with streak diseases of sugar cane and Panicum maximum. Ann Appl Biol 77: 289-296.
19. Rose DJ (1978) Epidemiology of maize streak disease. Annu Rev Entomol 23: 259-282.
20. Soto PE, Buddenhagen IW, Asnani VL (1982) Development of streak virus resistant maize populations through improved challenge and selection methods. Ann Appl Biol 100: 539-546.
21. Brunt A, Crabtree K, Dallwitz MJ, Gibbs A, Watson L (1990) Viruses of tropical plants-descriptions and lists from the vide database. CAB International /ACIAR, Wallingford, USA.
22. Thottappilly G, Bosque-Pérez NA, Rossel HW (1993) Viruses and virus diseases of maize in tropical Africa. Plant Pathol 42: 494-509.
23. Willment JA, Martin DP, Rybicki EP (2001) Analysis of the diversity of African streak mastreviruses using PCR-generated RFLPs and partial sequence data. J Virol Methods 93: 75-87.
24. Shepherd DN, Martin DP, van der Walt E, Dent K, Varsani A, et al. (2010) Maize streak virus: An old and complex 'emerging' pathogen. Mol Plant Pathol 11: 1-2.
25. Fajemisin JM, Cook GE, Okusanya F, Shoyinka SA (1976) Maize streak epiphytotic in Nigeria [Virus diseases, Cicadulina mbila, insect vectors]. Plant Disease Reporter.
26. Kyetere DT, Ming R, McMullen MD, Pratt RC, Brewbaker J, et al. (1999) Genetic analysis of tolerance to maize streak virus in maize. Genome 42: 20-26.
27. Alegbejo MD, Olojede SO, Kashina BD, Abo ME (2002) Maize streak mastrevirus in Africa: distribution, transmission, epidemiology, economic significance and management strategies. J Sust Agri19: 35-45.
28. Walkley A, Black IA 1934 An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. Soil Sci 37: 29-38.
29. Moll RH, Kamprath EJ, Jackson WA (1982) Analysis and interpretation of factors which contribute to efficiency of nitrogen utilization. Agron J 74: 562-564.
30. Bray RH, Kurtz LT (1945) Determination of total, organic, and available forms of phosphorus in soils. Soil Sci 59: 39-46.
31. Chapman HD, Pratt FP (1961) Ammonium vandate-molybdate method for determination of phosphorus. Methods of analysis for soils, plants and water 1:184-203.
32. Monjane AL, Harkins GW, Martin DP, Lemey P, Lefeuvre P, et al. (2011) Reconstructing the history of maize streak virus strain a dispersal to reveal diversification hot spots and its origin in southern Africa. J Virol 85: 9623-9636.
33. Bosque-Pérez NA, Buddenhagen IW (1999) Biology of Cicadulina leafhoppers and epidemiology of maize streak virus disease in West Africa. S Afr J Plant Soil 16: 50-55.
34. Reynaud B (1988) Transmission of viruses from the streak, stripe and mosarch of March by their vectors Cicadulinambila (Naude) and Peregrinusmaidis (Ashmead) Biological, genetic and epidemiological approaches to the vector-virus-plant relationship. These, University of Sciences and Techniques of Languedoc, France.
35. Ramusi M, Flett B (2016) Transmission of maize streak virus from grasses to maize. SA Graan/Grain Monthly Features. October 2012 edition.
36. Asanzi CM, Bosque-Perez NA, Buddenhagen IW, Gordon DT, Nault LR (1994) Interactions among maize streak virus disease, leafhopper vector populations and maize cultivars in forest and savanna zones of Nigeria. Plant Pathol 43: 145-157.
37. Bosque-Perez NA, Olojede SO, Buddenhagen IW (1998) Effect of maize streak virus disease on the growth and yield of maize as influenced by varietal resistance levels and plant stage at time of challenge. Euphytica 101: 307-317.
38. Fajemisin JM, Shoyinka SA, Williams LE, Gordon DT, Nault LR (1976)

Maize streak and other maize virus diseases in West Africa. In Proceedings, International maize virus disease colloquium and workshop, USA.

39. Twumasi-Afriyie S, Badu-Apraku B, Sallah PY, Haag W, Asiedu EA, et al. (1992) Development and release of Obatanpa, an intermediate maturing quality protein maize variety in Ghana. Crop Res Inst, Kumasi, Ghana.

40. Twumasi-Afriyie S, Sallah PY, Owusu-Akyaw M, Ahenkora K, Soza RF, et al. (2012) Development and utilisation of quality protein maize in Ghana. Crop Res Inst, Kumasi, Ghana.

41. Yeboah E, Kahl H, Arndt C (2012) Soil testing guide. Market-Oriented Agriculture Programme. Ministry of Food and Agriculture Bulletin. Accra, Ghana.

42. Amberger A (2006) Soil fertility and plant nutrition in the tropics and subtropics. IFA, International Fertilizer Industry Association, France.

43. Berggren D, Mulder J (1995) The role of organic matter in controlling aluminum solubility in acidic mineral soil horizons. Geochim Cosmochim Acta 59: 4167-4180.

44. Ogban PI, Effiong GS, Obi JC, Ibia T (2011) Characteristics, potentials, and constraints of wetland soils for agricultural development in AkwaIbom State, South-Eastern Nigeria. Nig J Agric Food Environ 7: 80-87.

45. Wang M, Zheng Q, Shen Q, Guo S (2013) The critical role of potassium in plant stress response. Int J Mol Sci 14: 7370-7390.

46. Dordas C (2008) Role of nutrients in controlling plant diseases in sustainable agriculture. A review. Agron Sustain Dev 28: 33-46.

47. Perrenoud S (1990) Potassium and Plant Health. (2nded), International Potash Institute, Bern, Switzerland.

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