Original Research Article

Spatial Distribution and Damage Severity of Citrus Leafminer (*Phyllocnistis spp*. Stainton) in Major Citrus Producing Regions of Tanzania

ABSTRACT

Field survey was conducted to determine the occurrence and damage severity of the citrus leafminer, *Phyllocnistiscitrella*Stainton (Lepidoptera: Gracilariidae) in major citrus producing regions of Tanzaniabetween December 2011 and September 2012.In total, 14,725 citrus trees and seedlings were assessed to determine the presence or absence of *P. citrella* as well as its associated damage severity. A total of 10,000 citrus trees (>5 years) were sampled from Morogoro Rural and Muheza Districts, while 4,725 nursery seedlings (<5 years) from Kinondoni District. The damage severity was assessed as described by Horsfall-Barratt scale. Results revealed that leafminers were recorded in nearly all surveyed areas. Kruskal Wallis analysis suggested minimal spatial distribution of the pest incidence among the surveyed locations. Kinondoni district recorded the highest (34.11%) leafminer incidence while Muheza district had the lowest (3.74). However, the damage severity indicated an increasing trend from December 2011 through June 2012 in nursery seedlings at Kinondoni. Weather variables (especially temperature) played an important role to the pest's development and perpetuation. Further studies need to be conducted to have a wider knowledge of the pest in all the citrus growing regions in the country.

Keywords: [Damage, Citrus Leafminer, Incidence, *Phyllocnistiscitrella*and Tanzania]

1. INTRODUCTION

Citrus production in Tanzania is comparatively low considering the world statistics. According to [1] citrus production increased from about 6,000 tons in 1970 to 52,054 tons in 1999, the highest ever attained in Tanzania. Thereafter, the yield continuously declined to 35,706 tons in 2009 despite the new orchards and plantations established since theearly 2000s. Largest area ever recorded under citrus was 42,475 ha in the year 2001. Abiotic stresses (drought and declined soil fertility) and biotic constraints (insect pests and diseases) are believed to have contributed to the decline in yield [2]. While some efforts have been initiated to address the disease problems (*Citrus tristeza*and *Xanthomonascampestris*pv. *citri*) and a few insect pests such as fruit flies (*Bactrocerainvadens* and other species) little has been done to address the citrus leafminer problem.

*Phyllocnistiscitrella*originates from South East Asia and has been dispersed widely on all continents and many islands where citrus trees are grown [3]. It is found in many citrus growing areas of the world, including Southeast Asia, Japan, Taiwan, Australia, East Africa, Mediterranean countries, and the Middle East [4, 5 and 6].

The larvae of *Phyllocnistis*sppduring severe infestations attack tender twigs which might end up causing die back and consequently reducing tree vigour and productivity [7]. The economic impact of leaf miner feeding on leaves must be determined through measurement of reduced leaf area for photosynthesis and resulting reduced canopy development for fruit production. This could result in an increase in time (years) for young trees to reach an adequate fruit bearing size or in a reduction in reproductive wood for next year's crops in bearing trees [8]. Moreover, other symptoms include serpentine mines usually on ventral surfaces (epidermis appearing as a silvery film over leaf mines) and the curling of leaves that may harbour mealy bugs. In heavy infestations succulent branches of green shoots and fruits may also be attacked [9 and 10]. The current study aimed to establish the pest status of citrus leafminer in major citrus growing regions of Tanzania. Specifically,the study was aimed to assess the incidence and leaf damage severity of *P.citrella* in major citrus producing regions of Tanzania.

2. MATERIAL AND METHODS

2.1 Study locations

A study was conducted at three-month intervals over one year from December, 2011 to September, 2012 in three regions; Tanga region (latitudes 5.3050^{o} S and longitude 38.3166^{0} E), Morogoro region (latitude 8.2306^{o} S and 36.9541^{0} E) whichare major citrus growing regions and Dar essaalam region (6.7924^{0} S and 39.2083^{0} E) whichis popularly known for its mass citrus seedling vendors. Citrus leafminer distribution and damage severity were assessed inthecitrus orchards of Tanga and Morogoro while the seedlings nurseries in Dar Es Salaam region were used as per citrus seedlings. One major citrus producing district was selected in each region as follows: Tanga (Muheza), Morogoro (Morogoro Rural) and Kinondoni district from Dar Es Salaam region (Figure 1).

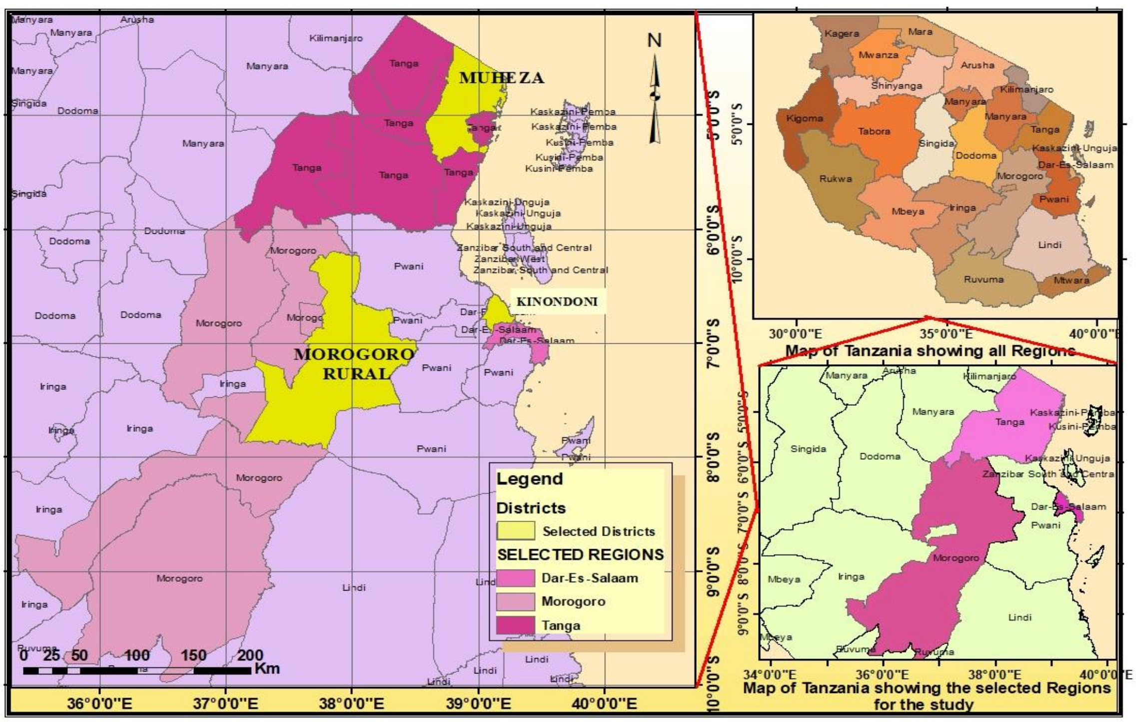

Figure 1: Map of Tanzania showing Regions and Districts of the Study Locations

2.2 Data collection

2.2.1 <u>Phyllocnistiscitrella</u> <u>incidence</u>

A field survey was conducted using transect across all passable roads in the selected districts (Muheza and Morogoro Rural). Citrus trees aged 5-15 years were randomly selected for assessment at 5 kilometre intervals. In each district 50 orchards were selected and 100 citrus trees were randomly sampled and examined. The number of citrustrees with characteristics leaf mines was counted and the percentage incidence was calculated as follows:

$$\frac{\text{Number of plants with leaf mines}}{\text{Total number of treesassessed}} \text{ X 100 = incidence (\%)}$$

Pre-established data collection sheet was used to capture other field information. The recorded information included the surveyed region, district, ward and/or village. Additionally geographical reference (GPS coordinates), field size, crop age, citrus varieties assessed, general health status, other pests (fruit flies, codling moths, parasitic plants) along with their respective damage symptoms. Similarly, bacterial canker symptoms were also recorded and farmers were interviewed for the citrus productivity, field's management history and associated predicaments affecting citrus production.

2.2.2 Phyllocnistiscitrella severity in nursery seedlings

A total of 4725 seedlings were randomly assessed from 25 citrus seedling vendors selected in Kinondoni district of Dar es Salaam region. Citrus seedlings with characteristic *P.citrella* leaf mines symptoms were counted and computed against total number of seedlings and the proportion value was thenmultiplied by 100 to obtain the percentage incidence on nursery trees.

$$\frac{\text{Number of citrus seedlings with leaf mines}}{\text{Total number of citrus seedlings assessed}} \text{ X 100 = Incidence (\%)}$$

The damage severity was assessed by scoring leaves with signs of serpentine mines as described in Horsfall Barratt scale as follows*Bock, et al., 2009* [24]:

Table 1: Horsfall-Barratt scale

Horsfall-Barratt category	Percent ranges	True range	Midpoint for conversion
0	0	0	0
1	0±3	3	1.5
2	3±6	3	4.5
3	6±12	6	9
4	12±25	13	18.5
5	25±50	25	37.5
6	50±75	25	62.5
7	75±87	13	81.5
8	87±94	6	91
9	94±97	3	96.5
10	97±100	3	98.5
11	100	0	100

***Source**: Bock, et al., 2009* [11]

2.3 Data Analysis

Data on incidence were separately analysed by Z-test, the Microsoft Excel [12] and subsequently subjected to Kruskal Wallis analysis to quantify variations amongst locations and periods of assessment [12]. The null and alternative hypotheses were set for being tested as follows; Probability (α level of significance) was set at 5% (0.05), degrees of freedom (df): k-1; 4-1=3 and decision rule from χ^2 table at α=0.05 is 7.815 and therefore if the calculated χ^2>7.815 then the null hypothesis was to be rejected. Moreover, data on damage scores were subjected to Kruskal Wallis analysis to deduce their temporal variations and the means were plotted to show severity progress curve so as to deduce pest's build up.

2.4 Results

The highest*P. citrella* incidences were recorded in March and reached its peak at Matombo decreasing through June while the lowest was recorded in December especially at Muheza and September at Matombo (Morogoro rural) (Fig.2).

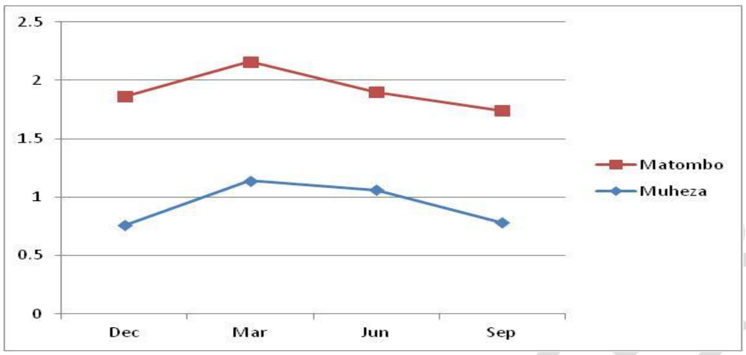

Figure 2: Effects of time interval (months) on *P. citrella* incidence in Morogoro rural and Muheza districts

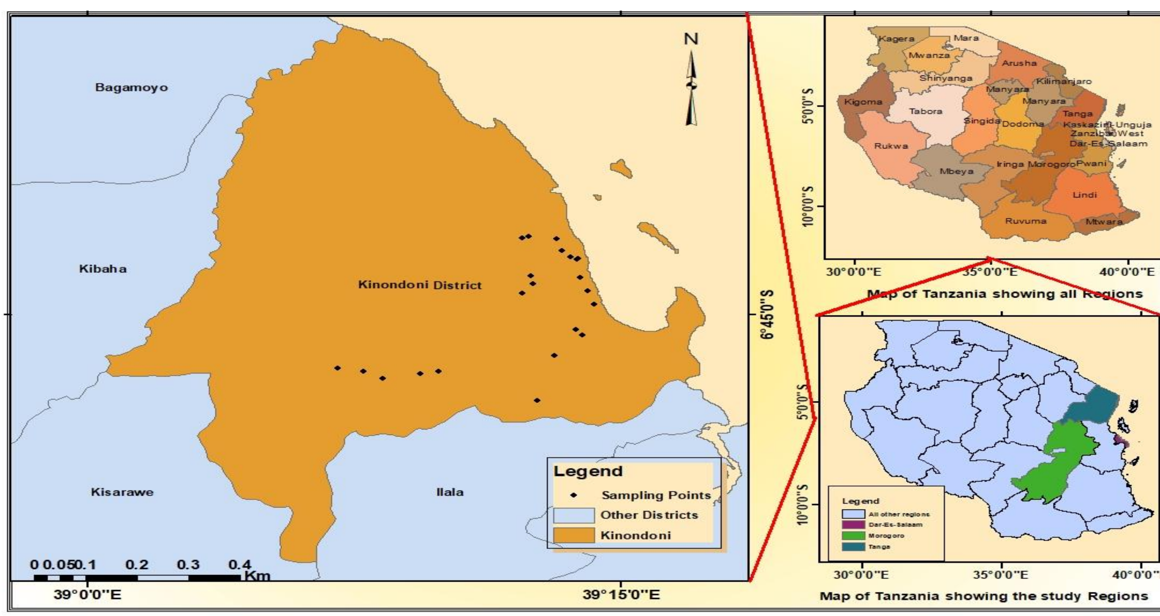

Figure 3: Map of Tanzania showing the Sampling Locations in Kinondoni Districts

In Kinondoni district (Figure 3) whereby citrus seedlings were surveyed a slightly higher level of infestation was observed compared to Muheza and Matombo. Kinondoni had an average percentage incidence of 34.11 % while Muheza recorded the least incidence (Table 2).

Table 2: Comparison of the *P. citrella*incidence among the study locations

Parameter	Kinondoni	Muheza	Matombo
Crop age (Years)	1.7	7.98	10.28
Mean Incidence (%)	34.11	3.74	4.26
StDev	0.69	0.19	0.26
H-B scale	4.96	1.12	1.22

Amongst 100 citrus fields surveyed in Morogoro Rural and Muheza districts (Figure 4), 74 had citrus trees of between 5-10 years of age and 26 fields had trees with more than 10 years of age (Table 3). All the 25 nurseries surveyed in Kinondoni district had citrus seedlings with less than 5 years of age. Citrus leafminers were recorded on about 16 plants in each field with less than 5 years old citrus trees.

Table 3: Correlation between plant age and damage severity of leaf miners

Crop Age (years)	Number of fields	Average mined trees
<5	25	16
5-10	74	1
>10	26	1

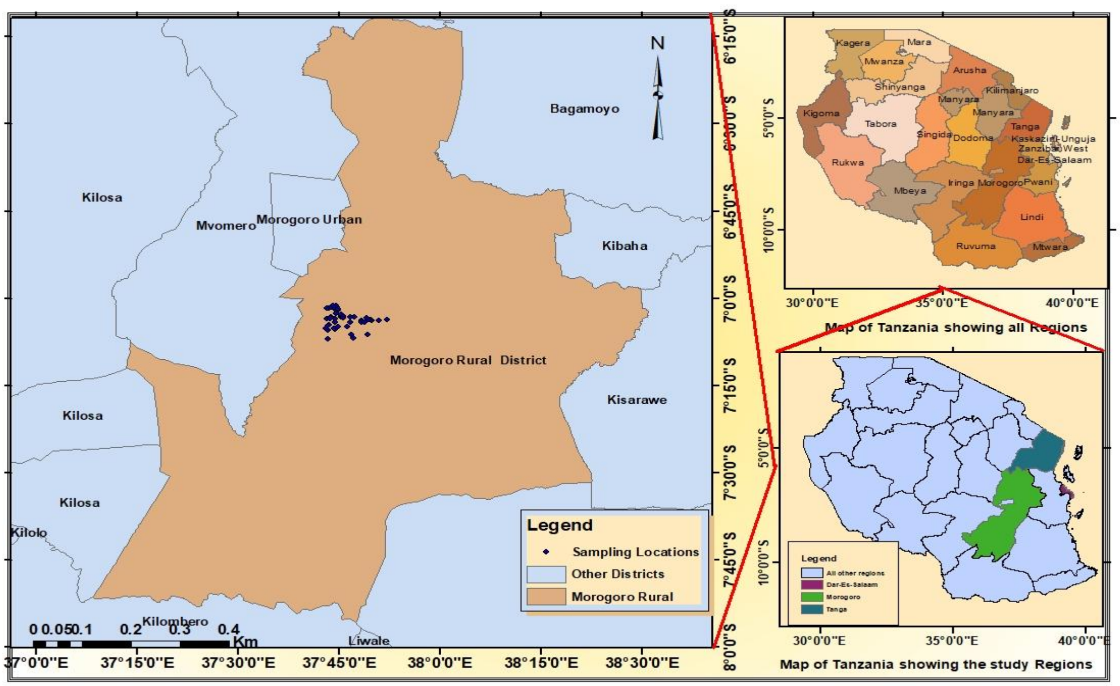

Figure 4: Map of Tanzania showing the Sampling Locations in Morogoro Rural Districts

Crop age had significantly (P = .05) affected *P. citrella* incidence among the three districts surveyed (Table 2). Kinondoni district recorded the highest (34.11%) *P. citrella* incidence and lowest crop age compared to other districts. However, Muheza (Figure 6)district had the lowest (3.74) citrus leafminer incidence while Matombo recorded to had the highest crop age.

In Kinondoni where the severity of the pest attack was assessed on young seedlings, it was found out that severity increased with time despite of the control measures employed by seedling vendors. The percentage severity of the plots assessed by Horsfall-Barratt scale was plotted against the time of assessment and showed an increase from December 2011 to September 2012 as shown in figure 5 below.

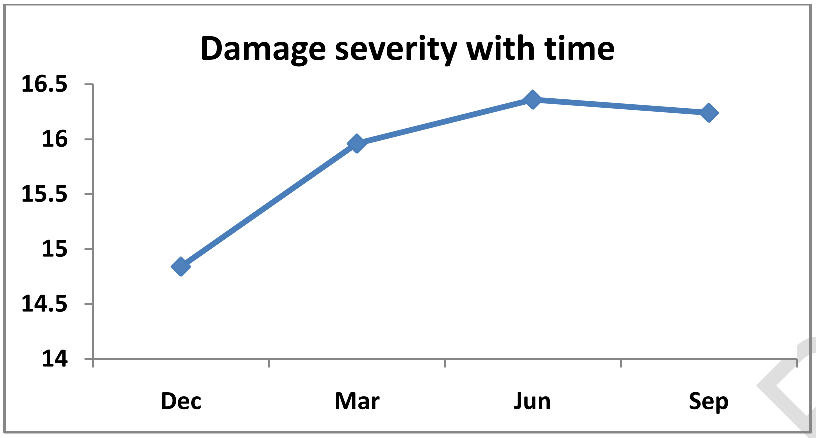

Figure 5: **Means of damage severity against time of survey at Kinondoni in 2012**

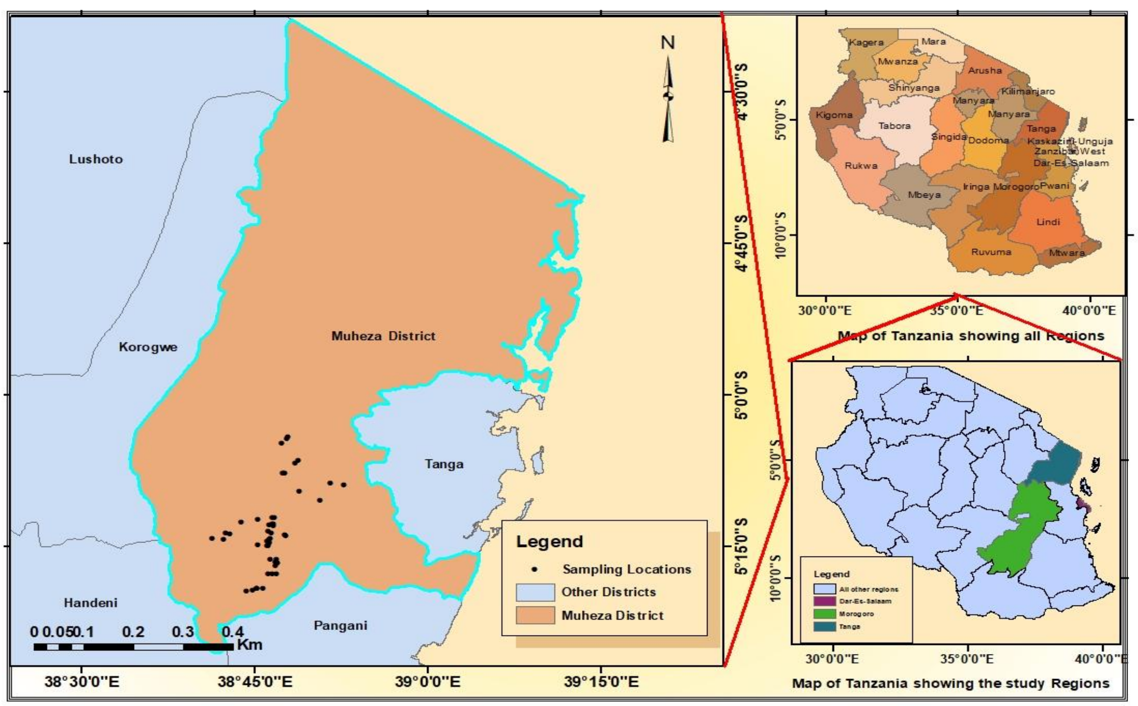

Figure 6: **Map of Tanzania showing the Sampling Locations in Muheza Districts**

2.5 Discussion

The infestation levels had increased soon after rainy seasons (March). In this period, the crop produces new flushes thus attract high infestation by the pest. However, the infestation decreased to a certain level in September through June. The increase in March could be attributed to the availability of new shoots and increase in temperature which is an important environmental factor for the pest to survive and perpetuate. The seasonality of the citrus leafminer correspond the report by [13] in Florida and [14] in southern Texas, where the leafminer densities increased from spring to fall and decline during the winter. However, [15]reported a negative correlation between shoots and leafminer abundance while it was positively affected by weather variables especially temperature. In this study, the decrease in the number of leafminer especially in September could be due to the low amount of rain, temperature and subsequently decreased shoots and low population abundance. This coincide report by [14]; [16]and [15] that with decrease in rainfall, the quantity of shoots could be affected and bring the citrus leafminer number down, which would be reflected as a decrease in monitored shoots. This situation could partially explain the decrease in the population abundance of citrus leafminer in these years.

This could be attributed to crop age in the surveyed sites which was above 5 years, averaged at 7.98 and 10.28 years respectively. Therefore the pest relied only on new flushes of leaves for they are known to prefer tender leaves in citrus crops of below 5 years of age. In Kinondoni District whereby citrus seedlings were surveyed, a slightly higher level of infestation was observed compared to Muheza and Morogoro Rural. Kinondoni had higher percentage incidence of leafminer in the study locations. This number was large compared to an average of 1 tree in fields with citrus trees of 5 to 10 and above 10 years old. More so, [17]and [18]observed similar results when studying leafminers' life cycle and revealed their dependency on young tender leaves for laying eggs and feeding during their larval stage.

The study indicated that in both sites the probability is less than 5% (P = .05). Therefore, we do not reject the null hypothesis and concluded that there is no temporal variation between sampling dates within the location. Generally, the pest level was very low to almost negligible in Morogoro Rural and Muheza which was due to crop age amongst other factors like temperature [19]. The crops in Morogoro Rural were10.82 years on average, hence not supporting pest colonisation. In Muheza, it was averaged 7.98 years of age and was literally still young but did not favour pest's growth. These observations were confirmed by [18] that the pest is favoured by crops that are less than five years of age.

However, the increasing trend stopped in June and between June and September there was a decrease in damage severity. Based on weather parameters, June is usually onset of dry season characterized by low moisture, low relative humidity and low temperatures. These conditions are not suitable for reproduction and perpetuation of leafminer [20]. It was also reported that the optimum temperature range for the survival and development of *P. citrella* was from 20^{0}C (minimum) and 30^{0}C (maximum) [19].

Rainfall seems to have greatly influenced the population of *Phyllocnistis*spp. The general trend of the populations of the species seems to be associated with rainfall pattern. High populations were recorded during and soon after rainy seasons. This period is when trees produced new flushes of leaves. Another abiotic factor that had an influence on observed population trend is humidity. A study by [21] has shown that atmospheric humidity strongly influences the survival of the leafminer pupae and therefore concluded that increased population of citrus leafminer is directly related to increase in relative humidity at the beginning of rainy season.

Temperature also might have influenced distribution of the pest. The pest had optimally survived at a temperature of 30^{0}C while females lived longer than males at all tested temperatures [19]. High numbers were recorded in the low and medium altitude areas of Kinondoni and Muheza districts compared to Morogoro Rural where it has a relatively cool temperature in some occasions. There is an inverse relationship between the infestation rate of *Phyllocnistis* spp. and the elevation at which fruits are found [22]. Similarly [23] considered the pest as lowland pest. Distribution of *Phyllocnistis* spp. might be limited by temperature as it has been reported by [21].

2.5 Conclusion and Recommendations

The study showed presence of citrus leafminer in all the study locations. This indicated that the pest is of wide spread and severe in most of the major citrus growing regions of Tanzania. Further studies need to be conducted to have a wider knowledge of the pest especially the genetic variability of the pestin all the citrus growing regions of the country. Farmers should be sensitized about the spread as well as affordable and sustainable control measures of leafminer in the country.

2.8 References

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APPENDIXI:Data Collected on the Incidence of Damage in Muheza District

Plot	FIELD SIZE (No. of trees)	CROP AGE (years)	DEC	MAR	JUN	SEP	Average	Incidence (%)	STDEV	H-B scale	GPS LOCATION
1	100	6	2	2	4	2	2.5	10	1.00	1	S 05 08'55.20" E 38 52'48.40"
	100	6	1	3	4	2	2.5	10	1.29	1	S 05 08'44.30" E 38 51'34.80"
3	100	8	2	0	0	0	0.5	2	1.00	1	S 05 06'42.80" E 38 48'35.30"
4	100	8	0	0	0	0	0	0	0.00	0	S 05 06'30.30" E 38 48'50.00"
5	100	8	1	0	1	0	0.5	2	0.58	1	S 05 04'48.40" E 38 47'25.60"
6	100	7	0	0	1	1	0.5	2	0.58	1	S 05 04'10.70" E 38 47'54.40"
7	100	7	0	2	2	2	1.5	6	1.00	1	S 05 04'17.60" E 38 47'50.90"
8	100	7	1	1	1	1	1	4	0.00	1	S 05 07'46.90" E 38 47'41.60"
9	100	7	1	2	2	2	1.75	7	0.50	2	S 05 07'44.42" E 38 47'34.30"
10	100	7	2	2	2	2	2	8	0.00	1	S 05 07'43.10" E 38 47'30.90"
11	100	7	1	1	0	0	0.5	2	0.58	1	S 05 13'55.90" E 38 47'47.20"
12	100	8	0	0	0	0	0	0	0.00	0	S 05 13'50.30" E 38 47'40.00"
13	100	7	0	0	0	0	0	0	0.00	0	S 05 16'16.60" E 38 46'23.30"
14	100	7	2	1	1	1	1.25	5	0.50	1	S 05 16'14.90" E 38 46'54.60"
15	100	7	0	1	1	0	0.5	2	0.58	1	S 05 17'40.10" E 38 46'57.50"
16	100	8	0	2	2	2	1.5	6	1.00	1	S 05 16'40.60" E 38 46'59.90"
17	100	8	1	1	2	1	1.25	5	0.50	2	S 05 16'32.30" E 38 46'50.00"
18	100	8	1	2	2	1	1.5	6	0.58	2	S 05 16'54.80" E 38 46'48.20"
19	100	12	0	0	0	0	0	0	0.00	0	S 05 17'42.40" E 38 46'11.40"
20	100	12	0	1	0	0	0.25	1	0.50	1	S 05 17'40.40" E 38 46'32.20"
21	100	12	0	0	0	0	0	0	0.00	0	S 05 19'23.10" E 38 44'22.40"
22	100	10	0	2	0	0	0.5	2	1.00	1	S 05 19'18.70" E 38 44'54.40"
23	100	9	1	0	0	1	0.5	2	0.58	1	S 05 19'07.70" E 38 45'11.80"
24	100	9	1	1	1	0	0.75	3	0.50	1	S 05 19'10.30" E 38 45'44.20"
25	100	9	0	0	0	0	0	0	0.00	0	S 05 19'07.90" E 38 45'11.30"
26	100	9	1	1	1	1	1	4	0.00	1	S 05 19'07.60" E 38 45'11.70"
27	100	9	0	0	0	0	0	0	0.00	0	S 05 14'13.30" E 38 41'20.50"
28	100	9	0	0	0	0	0	0	0.00	0	S 05 14'18.00" E 38 42'19.60"
29	100	6	0	2	2	2	1.5	6	1.00	2	S 05 14'37.70" E 38 46'16.30"
30	100	10	0	0	0	0	0	0	0.00	0	S 05 14'30.20" E 38 46'10.10"
31	100	8	0	1	1	0	0.5	2	0.58	1	S 05 14'18.70" E 38 46'21.10"
32	100	6	3	4	3	3	3.25	13	0.50	3	S 05 14'57.40" E 38 46'12.90"
33	100	6	3	2	2	2	2.25	9	0.50	3	S 05 14'55.00" E 38 46'08.20"
34	100	6	2	2	2	2	2	8	0.00	2	S 05 14'50.30" E 38 45'19.30"
35	100	6	1	3	3	2	2.25	9	0.96	3	S 05 14'35.20" E 38 46'16.50"
36	100	6	2	2	2	2	2	8	0.00	3	S 05 14'10.30" E 38 46'26.00"
37	100	6	2	2	3	2	2.25	9	0.50	3	S 05 12'55.30" E 38 46'39.39"
38	100	6	2	4	4	3	3.25	13	0.96	3	S 05 12'50.00" E 38 46'20.10"
39	100	12	0	1	0	0	0.25	1	0.50	1	S 05 12'46.60" E 38 46'40.50"
40	100	12	0	0	0	0	0	0	0.00	0	S 05 12'44.10" E 38 46'33.70"
41	100	12	0	1	0	0	0.25	1	0.50	1	S 05 12'36.80" E 38 43'51.10"
42	100	11	0	1	1	0	0.5	2	0.58	1	S 05 12'18.80" E 38 45'18.90"
43	100	10	0	0	0	0	0	0	0.00	0	S 05 12'08.70" E 38 46'46.20"
44	100	7	0	2	0	0	0.5	2	1.00	1	S 05 12'07.40" E 38 46'32.40"
45	100	7	2	0	0	0	0.5	2	1.00	1	S 05 13'45.30" E 38 42'55.50"
46	100	7	0	0	0	0	0	0	0.00	0	S 05 13'40.80" E 38 42'32.30"

47	100	6	0	1	0	0	0.25	1	0.50	1	S 05 13'39.80" E 38 46'27.00"
48	100	6	1	1	1	1	1	4	0.00	1	S 05 13'30.10" E 38 46'12.80"
49	100	6	1	1	0	0	0.5	2	0.58	1	S 05 09'34.70" E 38 48'55.60"
50	100	6	1	2	2	1	1.5	6	0.58	2	S 05 10'28.10" E 38 50'44.20"
	100	**7.98**	**0.76**	**1.14**	**1.06**	**0.78**	**0.935**	**3.74**	**0.19**	**1.12**	

APPENDIX II: Data Collected on the Incidence of Damage in Morogoro District

PLOT	FIELD SIZE (NO. OF TREES)	CROP AGE (YEARS)	DEC	MAR	JUN	SEP	AVERAGE	INCIDENCE (%)	STDEV	H-B SCALE	GPS LOCATION

1	100	8	3	3	3	1	2.5	10	1.00	3	S 07 03'44.00" E 37 49'31.10"
2	100	8	3	2	2	2	2.25	9	0.50	3	S 07 03'46.20" E 37 49'52.20"
3	100	8	1	1	2	2	1.5	6	0.58	2	S 07 03'43.60" E 37 49'48.10"
4	100	8	2	2	2	2	2	8	0.00	2	S 07 03'49.00" E 37 51'01.60"
5	100	7	2	1	1	1	1.25	5	0.50	2	S 07 03'49.20" E 37 48'22.60"
6	100	8	1	1	1	2	1.25	5	0.50	1	S 07 03'42.60" E 37 49'24.50"
7	100	7	3	2	2	3	2.5	10	0.58	3	S 07 03'38.70" E 37 52'13.30"
8	100	7	2	2	1	2	1.75	7	0.50	2	S 07 03'26.10" E 37 48'68.30"
9	100	8	2	1	1	1	1.25	5	0.50	1	S 07 03'32.60" E 37 44'26.10"
10	100	7	3	0	0	2	1.25	5	1.50	1	S 07 03'15.70" E 37 47'25.10"
11	100	19	0	1	0	1	0.5	2	0.58	1	S 07 03'16.20" E 37 46'42.10"
12	100	8	2	2	1	2	1.75	7	0.50	1	S 07 06'18.30" E 37 46'51.60"
13	100	9	1	1	1	1	1	4	0.00	1	S 07 06'16.30" E 37 49'18.50"
14	100	19	1	0	1	1	0.75	3	0.50	1	S 07 06'50.30" E 37 47'13.20"
15	100	19	1	1	1	1	1	4	0.00	1	S 07 04'08.50" E 37 48'20.40"
16	100	8	0	1	2	2	1.25	5	0.96	1	S 07 04'11.20" E 37 46'43.00"
17	100	8	2	2	2	2	2	8	0.00	1	S 07 04'10.60" E 37 48'48.20"
18	100	7	2	2	2	2	2	8	0.00	2	S 07 04'10.20" E 37 44'30.10"
19	100	8	2	0	0	0	0.5	2	1.00	1	S 07 04'54.70" E 37 46'17.10"
20	100	7	4	2	2	2	2.5	10	1.00	2	S 07 04'53.10" E 37 44'54.40"
21	100	7	3	1	1	2	1.75	7	0.96	2	S 07 05'20.30" E 37 44'30.60"
22	100	7	4	1	1	0	1.5	6	1.73	2	S 07 05'12.80" E 37 44'18.20"
23	100	7	3	1	0	0	1	4	1.41	1	S 07 06'58.20" E 37 43'20.20"
24	100	11	1	0	0	0	0.25	1	0.50	1	S 07 05'30.80" E 37 43'22.30"
25	100	11	1	1	0	0	0.5	2	0.58	1	S 07 05'10.50" E 37 43'10.40"
26	100	11	1	1	0	0	0.5	2	0.58	1	S 07 04'40.20" E 37 43'30.40"
27	100	11	1	1	1	1	1	4	0.00	1	S 07 04'44.40" E 37 43'20.20"
28	100	11	1	1	1	1	1	4	0.00	1	S 07 01'56.80" E 37 44'54.70"
29	100	15	1	0	0	0	0.25	1	0.50	1	S 07 01'54.40" E 37 44'30.20"
30	100	15	1	1	0	1	0.75	3	0.50	1	S 07 01'40.20" E 37 44'45.40"
31	100	15	2	1	1	1	1.25	5	0.50	1	S 07 01'34.70" E 37 44'47.30"
32	100	15	1	0	1	1	0.75	3	0.50	1	S 07 01'38.50" E 37 44'36.30"

33	100	18	1	1	1	1	1	4	0.00	1	S 07 01'35.60" E 37 44'18.70"
34	100	15	2	2	0	0	1	4	1.15	1	S 07 01'43.80" E 37 43'35.30"
35	100	20	1	1	0	1	0.75	3	0.50	1	S 07 01'33.40" E 37 43'56.20"
36	100	20	1	0	1	1	0.75	3	0.50	1	S 07 01'44.60" E 37 43'18.70"
37	100	6	1	1	2	0	1	4	0.82	1	S 07 03'18.30" E 37 43'48'20"
38	100	6	2	1	1	1	1.25	5	0.50	1	S 07 01'52.00" E 37 44'55.10"
39	100	8	1	0	0	1	0.5	2	0.58	1	S 07 03'30.50" E 37 43'12.20"
40	100	6	2	2	1	1	1.5	6	0.58	1	S 07 03'33.30" E 37 43'40.60"
41	100	6	1	2	1	1	1.25	5	0.50	1	S 07 03'22.20" E 37 43'54.00"
42	100	10	0	1	0	0	0.25	1	0.50	1	S 07 03'06.40" E 37 45'20.50"
43	100	6	2	1	1	0	1	4	0.82	1	S 07 03'13.30" E 37 45'22.20"
44	100	6	1	1	1	1	1	4	0.00	1	S 07 03'14.10" E 37 45'34.60"
45	100	11	0	0	0	0	0	0	0.00	0	S 07 03'20.50" E 37 45'40.00"
46	100	11	0	0	0	1	0.25	1	0.50	1	S 07 03'07.60" E 37 45'38.30"
47	100	13	0	0	0	0	0	0	0.00	0	S 07 02'44.40" E 37 45'26.30"
48	100	10	0	0	0	0	0	0	0.00	0	S 07 02'37.20" E 37 44'41.60"
49	100	9	0	1	0	0	0.25	1	0.50	1	S 07 01'16.80" E 37 44'34.80"
50	100	9	0	1	0	0	0.25	1	0.50	1	S 07 01'17.40" E 37 44'07.60"
	100	10.28	1.44	1.02	0.84	0.96	1.065	4.26	0.26	1.22	

APPENDIX III: Data Collected on the Incidence of Damage in Kinondoni District

PLOT	FIELD SIZE (No. of trees)	CROP AGE (years)	DEC	MAR	JUN	SEP	Average	Incidence (%)	STDEV	H-B scale	GPS LOCATION
1	188	2	12	15	15	14	14	29.79	1.41	5	S 06 48'15.90" E 39 12'38.70"
2	140	2	10	10	12	10	10.5	30.00	1.00	5	S 06 48'14.40" E 39 24'14.40"
3	176	2	17	10	10	12	12.25	27.84	3.30	5	S 06 48'18.20" E 39 24'18.70"
4	90	2	8	8	7	7	7.5	33.33	0.58	5	S 06 47'15.60" E 39 09'22.60"
5	190	2	17	20	18	18	18.25	38.42	1.26	5	S 06 47'26.60" E 39 08'17.90"
6	224	2	18	18	16	16	17	30.36	1.15	5	S 06 47'02.00" E 39 07'02.50"
7	318	2	20	24	22	20	21.5	27.04	1.91	5	S 06 47'09.90" E 39 07'45.20"
8	200	2	13	17	15	19	16	32.00	2.58	5	S 06 47'08.80" E 39 09'53.10"
9	302	1.5	24	24	28	26	25.5	33.77	1.91	5	S 06 46'34.20" E 39 13'09.10"
10	278	2	18	17	20	20	18.75	26.98	1.50	5	S 06 45'45.60" E 39 13'55.10"
11	122	2	10	12	12	14	12	39.34	1.63	5	S 06 45'33.00" E 39 13'44.30"
12	64	2	4	6	8	6	6	37.50	1.63	5	S 06 44'35.90" E 39 14'15.90"
13	98	2	4	8	8	8	7	28.57	2.00	5	S 06 44'35.40" E 39 14'16.00"
14	188	2	11	11	12	14	12	25.53	1.41	4	S 06 44'04.80" E 39 14'05.00"
15	230	1	16	18	18	19	17.75	30.87	1.26	5	S 06 43'48.70" E 39 12'32.40"
16	200	1	15	16	16	17	16	32.00	0.82	5	S 06 44'10.30" E 39 12'14.60"
17	212	1	18	20	21	18	19.25	36.32	1.50	5	S 06 43'30.60" E 39 12'28.20"
18	184	1	17	18	19	19	18.25	39.67	0.96	5	S 06 43'34.70" E 39 13'52.40"
19	170	1	16	16	17	16	16.25	38.24	0.50	5	S 06 42'50.20" E 39 13'48.10"
20	164	1	13	16	16	18	15.75	38.41	2.06	5	S 06 42'53.00" E 39 13'47.00"
21	124	2	15	16	15	14	15	48.39	0.82	5	S 06 42'46.90" E 39 13.36.20"
22	180	2	15	15	17	18	16.25	36.11	1.50	5	S 06 42'32.70" E 39 13.20.10"
23	200	2	17	20	20	18	18.75	37.50	1.50	5	S 06 42'06.40" E 39 13'11.60"
24	260	1	23	24	24	23	23.5	36.15	0.58	5	S 06 42'04.20" E 39 12'14.20"
25	220	2	20	20	23	22	21.25	38.64	1.50	5	S 06 42'00.40" E 39 12'24.30"
	188.88	**1.70**	**14.84**	**15.96**	**16.36**	**16.24**	**15.85**	**34.11**	0.69	4.96	