

# Original Research Article

## Environment and Weather variability Influence Influence on Occurrence and Damages of *Mononychellus tanajoa* Bondar on Selected Cassava Varieties in the Lake Zone, Tanzania

### ABSTRACT

A study was conducted in the Lake Zone, the leading cassava producing Zone in Tanzania during the 2015 and 2016 dry seasons. It aimed at establishing the influence of the weather variables on the occurrence and damages caused by of Cassava green mites (CGM), *M. tanajoa* and the influence of the weather variables on the pest's damage on commonly grown cassava varieties. The experiments were laid out in a Split plot design with varieties as sub plots and locations as main plots. The three locations were; Ukiruguru, Ng'ombe and Kishiri sites the former two being in Misungwi and the other one later in Kwimba districts respectively. Infestation with of *M. tanajoa* was allowed to occur naturally. Results suggested that mites population and damage varied significantly ( $P < 0.05$ ) among varieties, data collection dates and locations in both years. Generally, Kwimba in 2015 and Ukiruguru in 2016 recorded the highest population of *M. tanajoa* while Ukiruguru had the lowest counts. The highest root yield was recorded at Ukiruguru in both seasons. Of the test varieties Liongo Kwimba, Naliende, Suma and Namikonga were comparatively the most susceptible varieties. Rainfall, relative humidity and temperatures contributed either positively or negatively to the survival, perpetuation of and damage by *M. tanajoa* in both seasons.

**Keywords:** Varieties, Cassava, Population, Damage, Dynamics and *M. tanajoa*

### 1. INTRODUCTION

Arthropods variably responds to seasonally unfavourable environmental conditions, mainly heat, cold, or drought. Migration to over seasoning habitats, dormancy ranging from quiescence to diapause, and acquired hardiness are three common adaptations that arthropods have developed to cope with temporarily adverse climatic conditions [1]. Several improved and commercial cassava varieties have been bred and officially released in Tanzania (mostly in 2010) targeting the improved yield and resistance to major diseases, but

**Comment [KD1]:** Include the insect order and family

**Comment [KD2]:** Write in full at first mentioning of scientific name

**Comment [KD3]:** This statement is not clear, Ukiruguru recorded lowest count for which year. Please recast the statement

**Comment [KD4]:** Arrange in alphabetical order

limited information exists on their response to the combined effect of *M. tanajoa* and the environment.

Cassava is a subsistence food to 200 million poor people in the African continent and **in the Brazil serves as food for millions of poor people and also** plays an important role in the generation of employment and income, especially for small and medium producers [2].

Cassava green mite: *Mononychellus tanajoa* Bondar. (Acari: Tetranychidae) is the most important among pests that attack cassava in Tanzania [4, 5]. *Mononychellus* sp. was first reported in the country in 1972 at Ukerewe Islands [5, 6]. It attacks mainly shoots and leaves of cassava reducing both photosynthetic rate and root dry matter [5]. Severely damaged leaves dry out and fall off, which can cause a characteristic candle stick appearance Moreover, as a result of the reduced plant growth, starch in the storage roots is slowed and sometimes even reversed. The root yield losses in the absence of any control measures can reach up to 50% [5]. Since its the first occurrence of *M. tanajoa* in East Africa, the pest has expanded its distribution to the entire cassava growing belts, where it causes estimated yield losses ranging between 30-80 % [3].

**Comment [KD5]:** Rearrange reference numbering

**Cassava green mite: *Mononychellus tanajoa* Bondar. (Acari: Tetranychidae) is the most important among pests that attack cassava in Tanzania [4, 5]. *Mononychellus* sp. was first reported in the country in 1972 at Ukerewe Islands [5, 6]. It attacks mainly shoots and leaves of cassava reducing both photosynthetic rate and root dry matter [5].** In the Lake zone, the pest is more devastating with losses ranging from 20% to 80% tuber yield loss if left uncontrolled (Anon, 1999). It is not known that if such variations are related to environmental differences or varied response of cassava varieties that are commonly grown.

**Formatted:** Font: Italic

**Formatted:** Font: Italic

47

48 Despite its importance and diverse use, cassava production in Tanzania (5462454 metric  
49 tons) and the rest of African countries (149479840 metric tons) is grossly low compared to  
50 world production statistics (256529314 metric tons) [7]. Several efforts have been made  
51 since mid-1980s by the Tanzanian National Root Crop Research Program and International  
52 organizations particularly the International Institute of Tropical Agriculture (IITA) to breed for  
53 new varieties with acceptable agronomic qualities mainly yield. From 1990s to date, the  
54 breeding efforts were diverted to management of viral diseases, the Cassava Mosaic  
55 Disease (CMD) and Cassava Brown Streak Disease (CBSD). Such efforts have greatly  
56 addressed disease problems although has not improved the production to great extent.  
57 Excerpts in production data from early 2000s to date indicates that the cassava production in  
58 Tanzania ranges from 45737 (in 2003) to 57.228 tons/ha (in 2012) which is far less than that  
59 of India, 262,400 (in 2003) and 364,770 tons/ha (in 2012) in Asian countries [7]. As such  
60 many other biotic and abiotic production constraints remain to be addressed among which  
61 cassava green mite. **It attacks the shoots/leaves and reduces photosynthetic rate or the  
62 root dry matter [8]. Severely damaged leaves dry out and fall off, which can cause a  
63 characteristic candle stick appearance Moreover, as a result of the reduced plant  
64 growth, starch in the storage roots is slowed and sometimes even reversed. The root  
65 yield losses in the absence of any control measures can reach up to 50% [8].**

66 Researches that are geared towards understanding the ecology and the importance of the  
67 pest in relation to the environmental variables in the Lake Zone are scarce. The current  
68 studies were aimed at exploring these facts on *M. tanajoa*. The outcome(s) could be useful  
69 in designing strategies to manage *M. tanajoa* to minimum damage threshold level and  
70 subsequent losses in Tanzania.

71

## 72 2.0 Material and Methods

**Comment [KD6]:** Write this value in a correct manner to indicate if the production is million or thousand metric tons

**Comment [KD7]:** ?

**Comment [KD8]:** ?

**Comment [KD9]:** This has been stated before

Mwanza region is located in the Lake Zone , the leading cassava producing zone that accounts for **about** 37.43% of the total cassava in Tanzania, followed by the Southern zone, 26.50%; the Eastern zone, 12.36%; while the remaining other five zones produce only 24.15% of the cassava root yield in the country [9]. Three different field trials were conducted **in for** two consecutive years (2015 and 2016) to assess the **environmental influence of weather variability (different location) influence** on the occurrence and damage of *M. tanajoa* on commercial and popular local cassava varieties. The three sites, Ukiruguru Lake Zone Agricultural Research and Development Institute (LZARDI) located at 02° 43.156'S, 033° 01.43'E and 4000m above sea level, N'gombe village located at 02° 45.743'S and 033° 01.838'E and 3888m above sea level and Kishiri village located at 02° 48.694'S, and 033° 22.161'E and 4023 m above sea level in Misungwi and Kwimba districts respectively, were selected for the experiments (Figure 1). Nine different cassava varieties (Naliendele, Kiroba, Meremeta, Belinde, Lioigo Kwimba, Suma, Mkombozi, Kyaka and Namikonga) were planted at each location and these were randomized into nine plots in a Split Plot Design with locations as main plots while varieties as sub plots and these were replicated three times making a total of twenty seven plots. The treatments were allocated to a plot size of 36m<sup>2</sup> with 1m path (boarder) between plots and 2m between blocks, respectively. One stem cutting (30cm long) was planted at a spacing of 1x1m within and between rows giving a total of 10000 plant population ha<sup>-1</sup> in a 1924m<sup>2</sup> plot. This was allowed under natural infestation by the mites.

## **2.1 Population assessment of *M. tanajoa***

Cassava green mite population was monitored at monthly intervals starting at three months after planting i.e from March and ending in September, **2015** respectively for each seasons. **This was taken** by the **physical visual** counting of the mites on the top fully open five leaves using a hand lens (Model No. YT1045/50mm). In each plot, eighteen cassava plants within a

net plot were sampled randomly for assessment while leaving out the border rows to avoid border effects [4].

## 2.2 Leaf damage assessment

The leaf damage was recorded using a scale of 1 to 5 (i.e. 1 means no obvious symptom, 2 = less than 5% of leaf chlorosis, 3 = more than 5% but less than 50% of leaf chlorosis, 4 = more than 50% of leaf chlorosis with significant reduction in leaf area and 5 = leaf is dead and has dropped) a result of the damage by the mites as reported by [10].

## 2.3 Statistical analysis

Collected data were subjected to analysis of variance (ANOVA) in a Split plot design using the GenStat software 15<sup>th</sup> edition [11]. Treatment means were compared using the Least Significant Difference (LSD) at 5% level of significance ( $P \leq 0.05$ ). While all the numerical data with low counts or zero values were transformed into  $\log y+1$  [12]. Yield data were taken in kilograms and subjected into  $\text{tons ha}^{-1}$ . Regression analysis was run to predict the effect of some weather variables on the population and damage of *M. tanajoa*.

## 3. RESULTS AND DISCUSSION

Results in fig. 4.2 indicated that both the population and damage of cassava green mite in the two seasons (2015 and 2016) were significant ( $P = .05$ ). Higher population and damage were recorded in 2016 compared to 2015. Moreover withinBetween the two seasons, the *M. tanajoa* population and damage were found to be significant ( $P = .05$ ) in 2015 with cassava planted in Kwimba recording the highest mites' population; followed by Ukiruguru while Ng'ombe had the lowest population (Fig. 4.3). Conversely, Ukiruguru recorded the highest damage followed by N'gombe while Kwimba had the least damage. However, the population and damage by cassava green mite was generally higher in 2016 compared to 2015, despite the insignificant difference among the three locations. The damage by *M. tanajoa* was significantly different ( $P = .05$ ) among the locations whereby the mites damage

**Comment [KD10]:** Present the data on weather variables for 2015 and 2016

**Comment [KD11]:** The result did not report on the varietal effect

**Comment [KD12]:** Give the population and damage value, more so your result was presented in figure

128 | in Kwimba and Ukiruguru were statistically similar while N'gombe having the highest level of  
129 | damage. A similar result by [13] revealed that a comparative analysis of *M. tanajoa*  
130 | population among districts indicated Kwimba and Misungwi districts of the Lake Zone  
131 | recorded the highest population compared to all other Zones in the country across the two  
132 | seasons.

133 |  
134 | The difference in the number and damage of the mites between years could be due to the  
135 | higher temperatures recorded in 2015 compared to 2016. Moreover, other factor such as  
136 | differences in varieties and other environmental variables especially rainfall and relative  
137 | humidity probably contributed to the perpetuation and damage by *M. tanajoa* [13]. The  
138 | higher population at Kwimba in 2015 could be attributed to **so many the fact that reasons**  
139 | **as** Kwimba is considered the driest among the locations, evident by the dry spell recorded  
140 | during the month of March when the sampling started and rainfall had declined thus account  
141 | for high mite density. **Initially the mite population was first observed in March, when the**  
142 | **sampling started and when the rainfall had declined. This could probably make it**  
143 | **higher especially at Kwimba** but decreased to a certain level in subsequent months,  
144 | especially at Ng'ombe and Ukiruguru at irregular intervals. This indicated that the dynamics  
145 | of the mite's population across locations was irregular with its peak at Kwimba in August and  
146 | June but drastically decreased to the lowest in July. This was also reported by [14] that high  
147 | *M. tanajoa* densities were proved to occur in an irregular pace. More so, drier conditions  
148 | might have encouraged the survival, perpetuation and distribution of cassava green mite.  
149 | Conversely, in 2016 low mite's population was observed suggesting the impacts of high  
150 | rainfall on the pest [13].

**Comment [KD13]:** There's conflict in the the two statement. Please reconcile

**Comment [KD14]:** I think the author name should be followed by 13 in pranthesis.

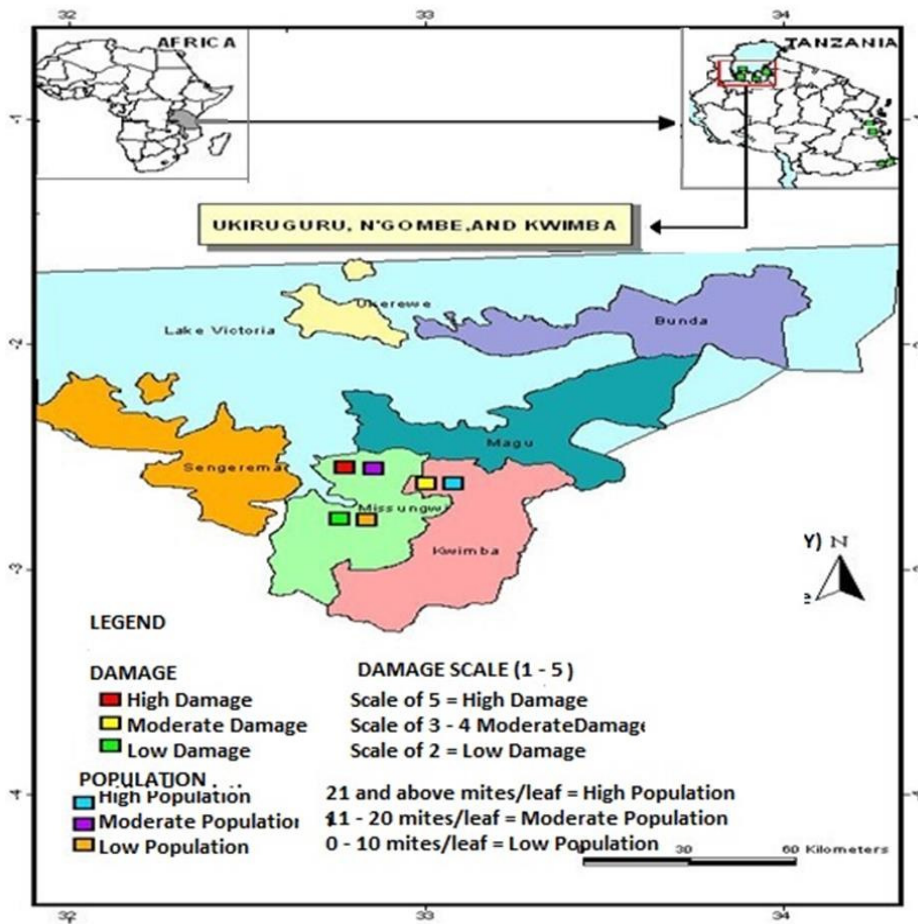
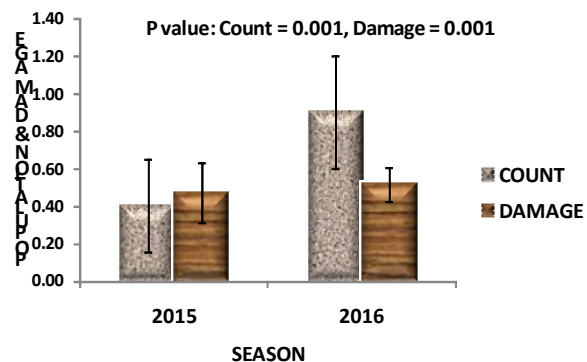
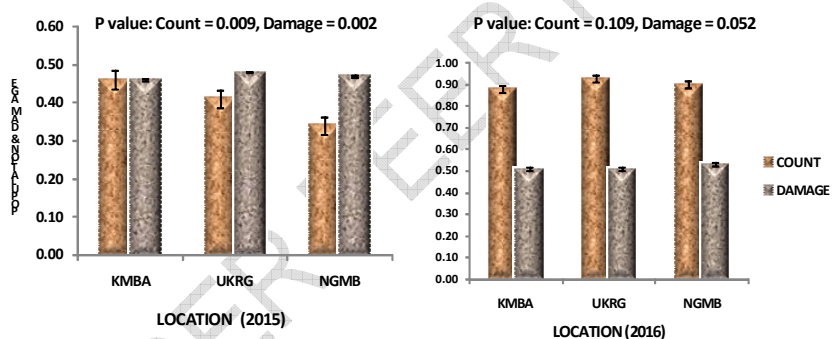


Figure 4.1: Map of Tanzania showing the study areas in Mwanza Region



SD $\pm$ : COUNT (2015) = 0.247, DAMAGE = 0.298COUNT (2016) = 0.157, DAMAGE = 0.094

Figure 4.2: Population and damage by *M. tanajoa* during 2015 and 2016 seasons.



SE $\pm$ : Count = 0.009 Damage = 0.002; SE $\pm$ : Count = 0.109 Damage = 0.052

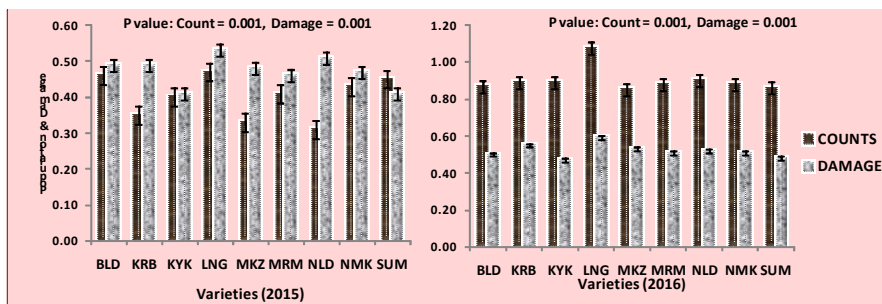
KEY: KMBA = Kwimba, UKRG = Ukiruguru, NGMB = N'gombe

Figure 4.3: *M. tanajoa* population and damage in three different locations in Mwanza region, Tanzania

The observed response of **some** cassava varieties to *M. tanajoa* in 2015 and 2016 was **as** shown (Fig. 4.4). There were significant ( $P \leq 0.05$ ) differences in the population and damage caused by *M. tanajoa* in both years among the cassava varieties on the population and damage caused by *M. tanajoa* in both years. Lingo Kwimba recorded the highest mite population number and damage in the two seasons while Naliendele recorded the lowest mite counts. However, Kyaka and Suma appeared to have the least damage in 2015. Several authors [3, 15, 16] reported that limited availability of fresh plant growth (during the main part of the dry season) and heavy rainfall (in the middle of the rainy season) are the factors keeping the pest populations low. The higher population at Kwimba in 2015 could be attributed to **so many reasons as Kwimba is considered the driest among the locations, thus inadequate and irregular rainfall recorded in the study area due to the onset of rainfall high mite density. Initially the mite population was first observed in March, when the sampling started and when the rainfall had declined. This could probably make it higher especially at Kwimba but mite population decreased to a certain level in subsequent months, especially at Ng'ombe and Ukiruguru at irregular intervals. This, which** indicated that the dynamics of the mite's population across locations was irregular with its peak **at Kwimba** in August and June at Kwimba but drastically decreased to the lowest in July. This was also reported by [14] that high *M. tanajoa* densities were proved to occur in an irregular space [3, 15, 16] Moreover, the damage was observed to fluctuate as reported by [10].

**Comment [KD15]:** Give the corresponding value of mite population and damage

**Comment [KD16]:** The only reason given here drought



$SE_{\pm}$ : Count = 0.025    Damage = 0.017                       $SE_{\pm}$ : Count = 0.033    Damage = 0.010

**Figure 4.4: Population dynamics and damage by *M. tanajoa* on commercial and popular Cassava Varieties in Mwanza region, Tanzania.**

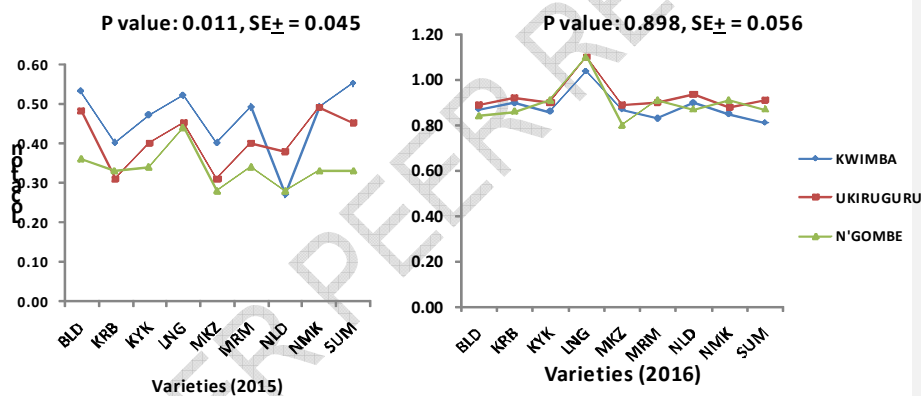


**Figure 4.5: The variation in *M. tanajoa* population on tested cassava varieties among the three experimental sites in Mwanza**

The performance of some cassava varieties to *M. tanajoa* population in three locations were found to be significant ( $P \leq 0.05$ ) (Fig.4.5). In 2015, Belinde and Liongo Kwimba varieties generally recorded higher number of mites infestation while Mkombozi and Naliendele had the lowest number of *M. tanajoa* across the locations. Similarly in 2016, Liongo Kwimba recorded the highest number of mites in all the three locations followed by Naliendele, Kyaka

**Comment [KD17]:** Give the full meaning of the abbreviations

**Comment [KD18]:** Are u trying to talk about the resistant or susceptibility of the cassava varieties?

214 | and Kiroba. The lowest mite count was recorded on Suma, Namikonga and Mkombozi at all  
 215 | the three study sites. This could be due to the inherent susceptibility or resistance/tolerant of  
 216 | the respective cassava varieties. Consequently, varietal differences as per the number and  
 217 | damage of *M. tanajoa* could not only be attributed to weather variables but also to the  
 218 | inherent characteristics of the genotype. Similar result was reported by [14, 17] that the  
 219 | variation in *M. tanajoa* population density among the genotype may be associated with  
 220 | factors inherent in the different genotypes. Moreover, in another research in Tanzania, [13]  
 221 | reported that generally, most of the cassava varieties found during the two diagnostic  
 222 | surveys were varied which might affect the differences and similarities that exist across the  
 223 | zones in the two years.

224 | The effects of the interaction between cassava varieties and location on the damage by *M.*  
 225 | *tanajoa* were not significant (Fig.4.6). However, in 2015, Liongo Kwimba recorded higher  
 226 | damage across the locations followed by Naliendele and Belinde with Suma having the  
 227 | lowest damage compared to other varieties. Similarly, Liongo Kwimba and Kiroba recorded  
 228 | higher damage in all the three locations in 2016 and Kyaka was found to have the least  
 229 | damage among all other varieties (Fig.4.7). In both years, the interaction effect between the  
 230 | tested varieties and locations on root weight ha<sup>-1</sup> was not significant (Fig.4.8). All the other  
 231 | eight varieties were found to be statistically similar. Moreover, among the other varieties,  
 232 | Meremeta performed better than the other seven other varieties. The lowest root weight was  
 233 | recorded by Liongo Kwimba in all the three locations in the order Ukiruguru, Kwimba and  
 234 | N'gombe respectively. The damage on cassava varieties led to high loss of the cassava  
 235 | leaves and subsequent reduction in the photosynthetic ability of the cassava and the yield,  
 236 | especially on the susceptible varieties. This has been reported by researchers that the  
 237 | damage has been equated to the loss of biomass and is an indicative loss of the leaf  
 238 | photosynthetic area [18].

**Comment [KD19]:** Give the corresponding value of the mite infestation

**Comment [KD20]:** Give the corresponding value in bracket

**Comment [KD21]:** Give the corresponding value in bracket

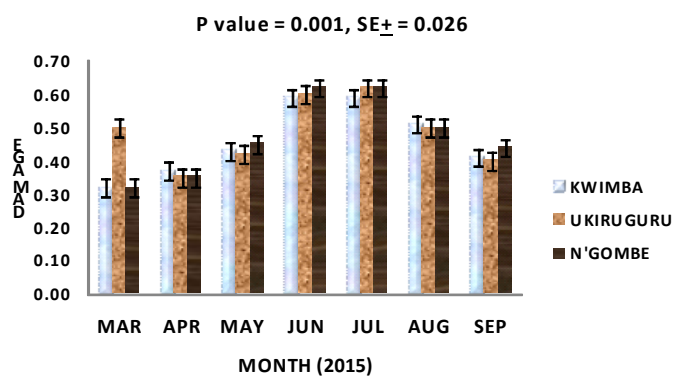


Figure 4.6: Interaction effects of cassava varieties and location on damage by *M. tanajoa* in the Mwanza region, Tanzania in 2015

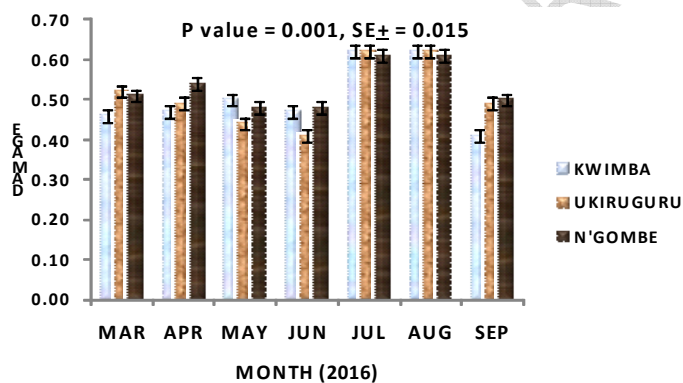


Figure 4.7: Interaction effects of cassava varieties and location on damage by *M. tanajoa* in the Mwanza region, Tanzania in 2016

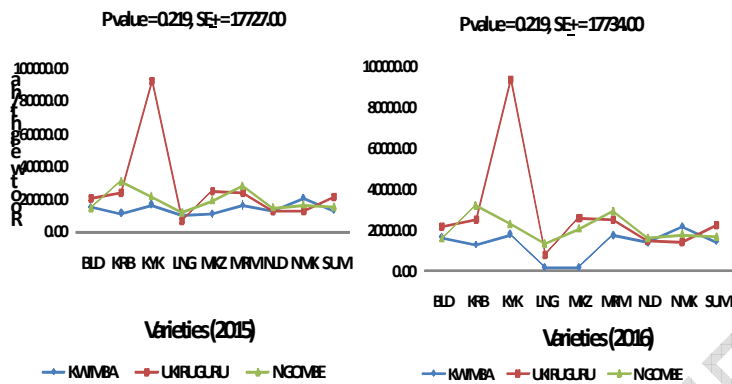


Figure 4.8: Interaction effects between variety and location on Average Root Weight ( $\text{kg ha}^{-1}$ ) as influenced by *M. tanajoa* in Mwanza region, Tanzania.

Table 4.1: Regression analysis of some weather variables against *M. tanajoa* count during 2015 and 2016 rainy and dry seasons in Mwanza region, Tanzania

| 2015 COUNT<br>Parameter | 2015 COUNT               |          |           | 2016 COUNT<br>Parameter | 2016 COUNT               |          |           |
|-------------------------|--------------------------|----------|-----------|-------------------------|--------------------------|----------|-----------|
|                         | Beta<br>( $\beta$ Value) | SE $\pm$ | P Value   |                         | Beta<br>( $\beta$ Value) | SE $\pm$ | P Value   |
| Constant                | 4.80                     | 1.37     | (0.001)** | Constant                | -7.99                    | 1.16     | (0.001)** |
| Rainfall                | 0.000574                 | 0.000261 | (0.028)*  | Rainfall                | -0.11429                 | 0.00834  | (0.001)** |
| RH                      | -0.0331                  | 0.0110   | (0.003)** | RH                      | -0.02773                 | 0.00286  | (0.001)** |
| Max. Temp               | -0.1788                  | 0.0566   | (0.002)** | Max. Temp               | 0.1273                   | 0.0239   | (0.001)** |
| Min. Temp               | 0.1449                   | 0.0523   | (0.006)*  | Min. Temp               | 0.3840                   | 0.0371   | (0.001)** |

Figures in parentheses are P values (significant at  $\leq 0.005$ )

Key: RH = Relative Humidity, Max. Temp. = Maximum Temperature, Min. Temp. = Minimum Temperature

**Table 4.2: Regression analysis of some weather variables against *M. tanajoa* damage during 2015 and 2016 rainy and dry seasons in Mwanza region, Tanzania**

| 2015 DAMAGE<br>Parameter | Beta<br>( $\beta$ Value) | SE $\pm$ | P Value   | 2016DAMAGE<br>Beta<br>( $\beta$ Value) | SE $\pm$ | P Value   |
|--------------------------|--------------------------|----------|-----------|----------------------------------------|----------|-----------|
| Constant                 | 3.890                    | 0.702    | (0.001)** | -1.159                                 | 0.353    | (0.001)** |
| Rainfall                 | 0.000786                 | 0.000134 | (0.001)** | -0.02350                               | 0.00255  | (0.001)** |
| RH                       | -0.00100                 | 0.00567  | (0.860)   | -0.013411                              | 0.0087   | (0.001)** |
| Max. Temp                | -0.0704                  | 0.0291   | (0.016)*  | 0.01907                                | 0.00728  | (0.009)** |
| Min. Temp                | -0.0692                  | 0.0268   | (0.010)*  | 0.1015                                 | 0.0113   | (0.001)** |

Figures in parentheses are P values (significant at  $\leq 0.005$ )

Key: RH = Relative Humidity, Max. Temp. = Maximum Temperature, Min. Temp. = Minimum Temperature

Multiple regression analysis was conducted to predict the effects of the weather variables on the population and damage of *M. tanajoa* in the Lake zone, Tanzania in 2015 and 2016 rainy and dry seasons (Table 4.1). Four weather variables (rainfall, relative humidity, and maximum and minimum temperatures) were simultaneously entered into the analysis and a question what was the percentage contribution of each of the dependent variables to the population and damage of *M. tanajoa*. The overall variance explained by the three predictors was 1.1% in 2015 and 34.3% in 2016 which means that all the predictors accounts for 1.1% (in 2015) and 34.3% variance to the number of *M. tanajoa* (in (in 2015) and 2016,) variance to the number of *M. tanajoa*. Rainfall and minimum temperature were positively correlated to the mites' count while relative humidity and maximum temperature were negatively related to *M. tanajoa* the population number of *M. tanajoa* in 2015 such as rainfall ( $\beta = 0.000574$ ,  $p \leq 0.028$ ), relative humidity ( $\beta = -0.0331$ ,  $p \leq 0.003$ ), maximum temperature ( $\beta = -0.1788$ ,  $p \leq 0.002$ ), and minimum temperature ( $\beta = 0.1449$ ,  $p \leq 0.006$ ) this explains that with increase in a unit of each variable (relative humidity and maximum temperature) will decrease *M. tanajoa* the population, number of *M. tanajoa*. However in 2016, there were

negative relationship between rainfall and relative humidity while it was positive with the maximum and minimum temperature. The fluctuations in damage caused by *M. tanajoa* within and across seasons could be attributed to differences in weather variables over time and space as well as inherent differences among the tested cassava varieties [17]. The difference in the number and damage of the mites between years could be due to the higher temperatures recorded in 2015 compared to 2016. Moreover, other factor such as differences in varieties and other environmental variables especially rainfall and relative humidity probably contributed to the perpetuation and damage caused by *M. tanajoa*. This explained that with an increase in unit of the rainfall and relative humidity, there will bewas decrease in the mites' counts in 2016 vice versa in the case of maximum and minimum temperatures [13, 17]. The variation in either positive or negative relationship between the two seasons could be attributed to the differences in amount of rainfall, relative humidity and temperatures received in each year thus, in 2016 there was higher amount of rainfall which if increased that will negatively affects the mites count. This indicated that with increase in a unit in rainfall in 2015 will subsequently increase mites' damage and vice versa in 2016.

**Comment [KD22]:** There are lot of repitition and waste of words here. Author should try to summarise the result

Table 4.2 shows that the relationship among the weather variable was significant ( $P \leq 0.05$ ). Rainfall was found to be positively correlated to *M. tanajoa* damage in 2015 and negatively in 2016. The relative humidity was negatively correlated to damage in both years while maximum and minimum temperatures were negatively correlated in 2015 and positively in 2016. The fluctuations in damage caused by *M. tanajoa* within and across seasons could be attributed to differences in weather variables over time and space as well as inherent differences among the tested cassava varieties.

Generally, the population and damage were higher in 2016 compared to 2015 which could be as a result of the higher amount of rainfall in 2015. Several researchers [13, 14, 15, 16, 17, 19 and 20] have reported a negative correlation between rainfall and number of mites.

This could be due to the fact that the population build-up of the pest started at the onset of the dry season or **closure end** of the rainy season which is May, while July to August were the peak periods and thus, the damage was subsequently higher. The damage led to high loss of the cassava leaves and subsequent reduction in the photosynthetic ability of the cassava and the yield, especially on the susceptible varieties. This has been reported by researchers that the damage has been equated to the loss of biomass and is an indicative loss of the leaf photosynthetic area [18].

#### 4. Conclusion

The present studies have indicated that in both years, cassava varieties had responded differently to *M. tanajoa* **infestation** at different locations and different times of the two seasons in Lake Zone, Tanzania. Generally, the population and damage were higher in 2016 compared to 2015 season but followed similar trends across months and locations. The regression of some weather variables against the population and damage **inflicted** by *M. tanajoa* in both seasons predicted that all the weather variables tested have contributed either positively or negatively to the survival, perpetuation of and damage by *M. tanajoa* in both seasons. However, more researches should be carried out, especially breeding and molecular research to improve the adapted locals especially Liongo Kwimba.

## 6.0 COMPETING INTERESTS

The Authors have declared that no competing interests exist.

## 7.0 REFERENCES

1. Zundel, C., Hanna, R., Scheidegger, U. and Nagel, P. Living at the Threshold: Where Does the Neotropical Phytoseiid Mite, *Typhlodromalus aripo* Survive the Dry Season? *Exp Appl Acarol.* 2007, 41:11 – 26.
2. Andre, R., Machi, F., de Cássia, N., Esteca, P., Bergamim Arthur, M. Adriani, G. and Arthur, V. A Review on *Mononychellus tanajoa* (Bondar, 1938) Pest of Cassava in Brazil. *Australian Journal of Basic and Applied Sciences*, 2014, 8(3): 342 – 348.
3. Yaninek, J. S., Moraes, G.J. and Markham, R.H. Handbook on the Cassava Green Mite (*Mononychellus Tanajoa*) in Africa: A Guide to Its Biology and Procedures for Implementing Classical Biological Control. 1989: IITA.pp140.
4. Évila, C. C., Adenir, V., Teodoro, A., Rêgo, S., Anilde, G., Maciel S. and Renato, S. Population structure and dynamics of the cassava green mite, *Mononychellus tanajoa* (Bondar) and the predator *Euseius ho* (DeLeon) (Acari: Tetranychidae, Phytoseiidae). *Arthropods*. 2012; 1(2): 55 - 62.
5. Nyiira, Z. M. Report of Investigation of Cassava mite, *Mononychellus tanajoa* (Bondar). Kawanda research Station, Kampala, Uganda. Unpublished report. 1972: 14pp.
6. Msabaha, M. A. M., Ndibaz, R.E. and Nyango, A.K. Cassava Research Advances in Tanzania for the Period 1930 – 1988. Tanzania Agricultural Research Organisation, Ministry of Agriculture and Livestock Development, Tanzania. 1988; 25pp.
7. Food and Agricultural Organization. FAOSTAT database [<http://www.fao.org>] 2013; site visited on 12th March, 2014.
8. Moraes, G. J. and Flechtman, C. H. W. (2008). Manual de Acarologia: acarologia básica e ácaros de plantas cultivadas no Brasil. Holos, Ribeirão Preto, Brazil.
9. Report on TZNY Cassava. Cassava: Adding Value for Africa. Driving demand for Cassava in Tanzania: 2012; Draft Report. 61pp.
10. Nukenine, E.N., Hassan, A.T., Dixon, A.G.O. and Fokunang, C.N. Population Dynamics of Cassava Green Mite, *Mononychellus tanajoa* (Bondar) (Acarina: Tetranychidae) as influenced by Varietal Resistance. *Pakistan Journal of Biological Sciences*. 2002; 5(2): 177 – 183.
11. GenStat, Genstat Statistical Analysis System (2004). SAS User's Guide Statistics 2004 Edition. Statistical Analysis System Institute, Cary.
12. Eric, S. Inference Fundamentals, Virginia Tech. Fall. STAT 5034/CRN 96072. Printing services. 20013; 540-231-6701, 1425 S. Main Street. 356 pp.

**Comment [KD23]:** Adopt a uniform style of presenting journal name

**Formatted:** Font: Italic

**Comment [KD24]:** ?

**Formatted:** Font: Italic

**Comment [KD25]:** ?

**Formatted:** Font: Italic

**Formatted:** Font: Italic

**Formatted:** Font: Italic

**Formatted:** Font: Italic

**Formatted:** Font: Italic

- 374 13. Wudil, B. S.; Rwegasira, G. M.; Kudra, A. B. and Jeremiah, S. Spatial and Temporal  
375 Distribution of Cassava Green Mite, *Mononychellus tanajoa* Bondar (Acarina:  
376 Tetranychidae) in Tanzania. Archives of Current Research International. 2017; In  
377 press.
- 378 14. Toko, M., Yaninek, J. S. and O'Neill, R. J. Response of *Mononychellus tanajoa*  
379 (Acari: Tetranychidae) to cropping systems, cultivars, and pest interventions.  
380 Environmental Entomology. 1996; 25: 237-249.
- 381 15. Onzo, A., Hanna, R. and Sabelis, M. W. Temporal and spatial dynamics of an exotic  
382 predatory mite and its herbivorous mite prey on cassava in Benin, West Africa.  
383 Environmental Entomology. 2005; 34: 866 – 874.
- 384 16. Hanna, R., Onzo, A. and Lingeman, R. Seasonal cycles and persistence of an  
385 acarine predator-prey system on cassava in Africa. Population Ecology. 2005;  
386 47:107-117.
- 387 17. Wudil B. S., Rwegasira, G. M., Kudra, A. B. and Jeremiah, S. Response of Some  
388 Cassava Varieties to *Mononychellus tanajoa* Bondar. (Tetrachynidae: Acarina)  
389 Infestation in the Lake Zone, Tanzania. 2016, 7(4): 1-9.
- 390 18. Akinlosotu, T. A. and Leuschner, K. Outbreaks of two new pests (*Mononychellus*  
391 *tanajoa* and *Phenacoccus manihoti* ) in southern Nigeria. Tropical Pest  
392 Management, 1981; 27: 247-250.
- 393
- 394 19. Teodoro, A. V., Klein, A. M. and Tschamtkke, T. Temporally mediated responses of  
395 the diversity of coffee mites to agro forestry management. Journal of Applied  
396 Entomology, 2009a, 133: 659 - 665.
- 397
- 398 20. Teodoro, A., Klein, A. M. and Reis, P. R. Agro forestry management affects coffee  
399 pests contingent on season and developmental stage. Agricultural and Forest  
400 Entomology, 2009a 11: 295 - 300.
- 401
- 402

Formatted: Justified

Formatted: Font: Italic

Formatted: Font: Italic

Formatted: Font: Italic