

**Weather Variability Influence on Occurrence and Damages of
Mononychellus tanajoa Bonder (Acarina: Tetranychidae) 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 was aimed at establishing the influence of the weather variables on occurrence and damages caused by Cassava green mites (CGM), *Mononychellus tanajoa* 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, the former two being in Misungwi and the other one in Kwimba districts respectively. Infestation 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 N'gombe had the lowest counts in both years. The highest root yield was recorded at Ukiruguru in both seasons. Liongo Kwimba, Naliendele, 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: Cassava, Damage, Dynamics, *M. tanajoa*, Population and Varieties,

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 improved yield and resistance to major diseases, but

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

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

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

38

39 In the Lake zone, the pest is more devastating with losses ranging from 20% to 80% tuber
40 yield loss if left uncontrolled [6]. It is not known that if such variations are related to
41 environmental differences or varied response of cassava varieties that are commonly grown.

42 Despite its importance and diverse use, cassava production in Tanzania (5462454 million
43 metric tons) and the rest of African countries (149479840 million metric tons) is grossly low
44 compared to world production statistics (256529314 million metric tons) [7]. Several efforts
45 have been made since mid-1980s by the Tanzanian National Root Crop Research Program
46 and International organizations particularly the International Institute of Tropical Agriculture

47 (IITA) to breed for new varieties with acceptable agronomic qualities mainly yield. From
48 1990s to date, the breeding efforts were diverted to management of viral diseases, the
49 Cassava Mosaic Disease (CMD) and Cassava Brown Streak Disease (CBSD). Such efforts
50 have greatly addressed disease problems although has not improved the production to great
51 extent. Excerpts in production data from early 2000s to date indicates that the cassava
52 production in Tanzania ranges from 45737 (in 2003) to 57.228 tons/ha (in 2012) which is far
53 less than that of India, 262,400 (in 2003) and 364,770 tons/ha (in 2012) in Asian countries
54 [7]. As such many other biotic and abiotic production constraints remain to be addressed
55 among which cassava green mite.

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

61

62 **2.0 Material and Methods**

63

64 Mwanza region is located in the Lake Zone, the leading cassava producing zone that
65 accounts for 37.43% of the total cassava in Tanzania, followed by the Southern zone,
66 26.50%; the Eastern zone, 12.36%; while the remaining other five zones produce only
67 24.15% of the cassava root yield in the country [8]. Three different field trials were conducted
68 for two consecutive years (2015 and 2016) to assess the influence of weather variability on
69 the occurrence and damage of *M. tanajoa* on commercial and popular local cassava
70 varieties. The three sites, Ukiruguru Lake Zone Agricultural Research and Development
71 Institute (LZARDI) located at 02° 43.156'S, 033° 01.43'E and 4000m above sea level,
72 N'gombe village located at 02° 45.743'S and 033° 01.838'E and 3888m above sea level and
73 Kishiri village located at 02° 48.694'S, and 033° 22.161'E and 4023 m above sea level in
74 Misungwi and Kwimba districts respectively, were selected for the experiments (Figure 1).

75 Nine different cassava varieties; Naliendele (NLD) Kiroba (KRB), Meremeta (MRM), Belinde
76 (BLD), Liongo Kwimba (LNG), Suma (SUM), Mkombozi (MKZ), Kyaka (KYK) and
77 Namikonga (NMK) were planted at each location and these were randomized into nine plots
78 in a Split Plot Design with locations as main plots while varieties as sub plots and these were
79 replicated three times making a total of twenty seven plots. The treatments were allocated to
80 a plot size of 36m² with 1m path (boarder) between plots and 2m between blocks,
81 respectively. One stem cutting (30cm long) was planted at a spacing of 1x1m within and
82 between rows giving a total of 10000 plant population ha⁻¹ in a 1924m² plot. This was
83 allowed under natural infestation by the mites.

84

85 **2.1 Population assessment of *M. tanajoa***

86 Cassava green mite population was monitored at monthly intervals starting at three months
87 after planting i.e from March and ending in September respectively for each seasons by the
88 visual counting of the mites on the top fully open five leaves using a hand lens (Model No.
89 YT1045/50mm). In each plot, eighteen cassava plants within a net plot were sampled
90 randomly for assessment while leaving out the border rows to avoid boarder effects [4].

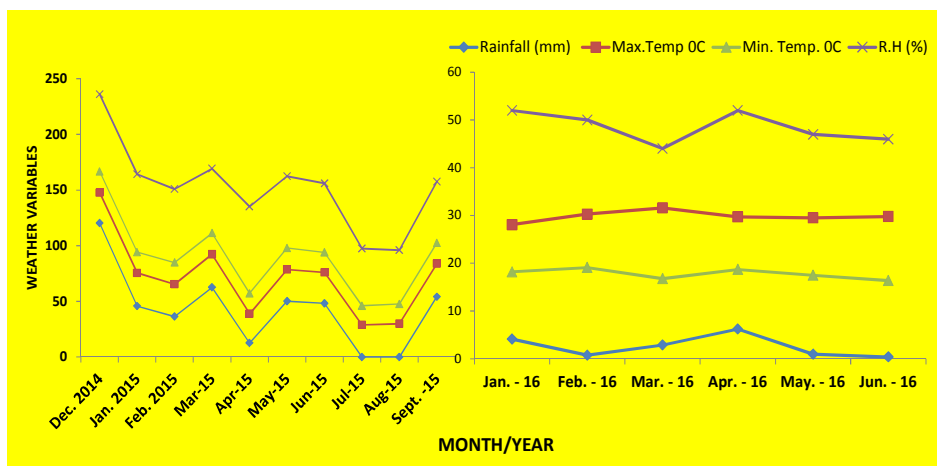
91 **2.2 Leaf damage assessment**

92 The leaf damage was recorded using a scale of 1 to 5 (i.e. 1 means no obvious symptom, 2
93 = less than 5% of leaf chlorosis, 3 = more than 5% but less than 50% of leaf chlorosis, 4 =
94 more than 50% of leaf chlorosis with significant reduction in leaf area and 5 = leaf is dead
95 and has dropped) a result of the damage by the mites as reported by [9].

96 **2.3 Statistical analysis**

97 Collected data were subjected to analysis of variance (ANOVA) in a Split plot design using
98 the GenStat software 15th edition [10]. Treatment means were compared using the Least
99 Significant Difference (LSD) at 5% level of significance ($P \leq 0.05$). While all the numerical
100 data with low counts or zero values were transformed into $\log y+1$ [1211]. Yield data were

101 taken in kilograms and subjected into tons ha⁻¹. Regression analysis was run to predict the
 102 effect of some weather variables on the population and damage of *M. tanajoa*.



103

104 Figure 1: Weather variables for 2015-2016 of the study areas in the Lake Zone, Tanzania

105

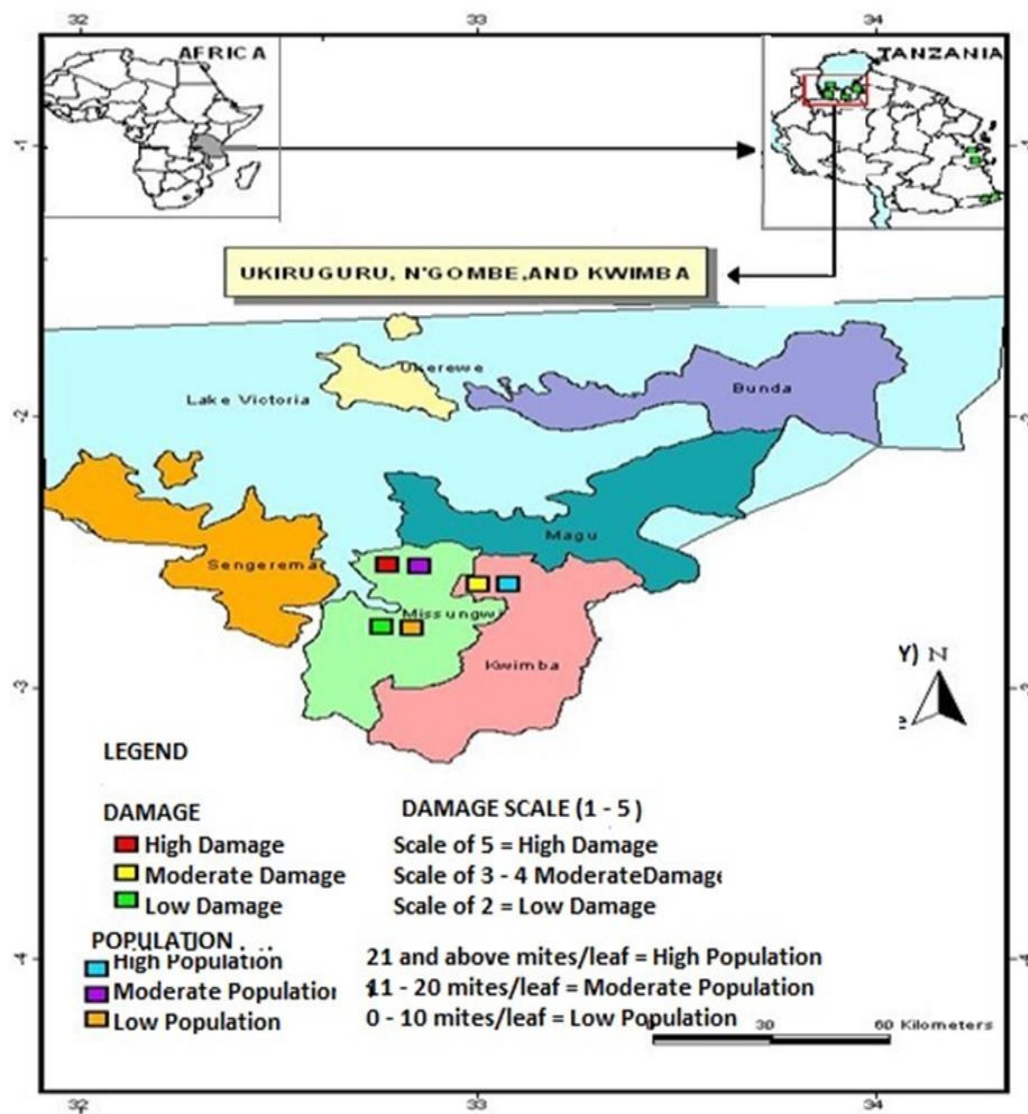
106 3. RESULTS AND DISCUSSION

107

108 Results in fig. 3 indicated that both the population and damage of cassava green mite in the
 109 two seasons (2015 and 2016) were significant ($P = .05$). Higher population and damage
 110 were recorded in 2016 compared to 2015. Between the two seasons, *M. tanajoa* population
 111 and damage were found to be significant ($P = .05$) in 2015 with cassava planted in Kwimba
 112 (0.46) recording the highest mites' population; followed by Ukiruguru (0.41) while Ng'ombe
 113 (0.34) had the lowest population (Fig. 4). Conversely, Ukiruguru (0.48) recorded the highest
 114 damage followed by N'gombe (0.47) while Kwimba (0.46) had the least damage during the
 115 2015 cassava growing season. Meanwhile, the damage by *M. tanajoa* was significantly
 116 different ($P = .05$) among the locations whereby Kwimba and Ukiruguru were statistically
 117 similar while N'gombe having the highest level of damage in 2016. However, the population
 118 by cassava green mite was generally higher in 2016 compared to 2015, despite the
 119 insignificant difference among the three locations. A similar result by Wudil *et al.*, [12]
 120 revealed that a comparative analysis of *M. tanajoa* population among districts indicated

121 Kwimba and Misungwi districts of the Lake Zone recorded the highest population compared
122 to all other Zones in the country across the two seasons.

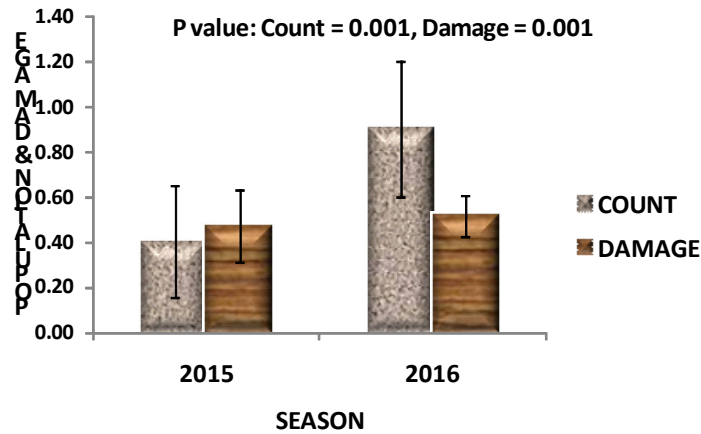
123 The difference in the number and damage of the mites between years could be due to the
124 higher temperatures recorded in 2015 compared to 2016. Moreover, other factor such as
125 differences in varieties and other environmental variables especially rainfall and relative
126 humidity probably contributed to the perpetuation and damage by *M. tanajoa* [12]. The
127 higher population at Kwimba in 2015 could be attributed to the fact that Kwimba is
128 considered the driest among the locations, evident by the dry spell recorded during the
129 month of March when the sampling started and rainfall had declined thus account for high
130 mite density but decreased to a certain level in subsequent months, especially at Ng'ombe
131 and Ukiruguru at irregular intervals. This indicated that the dynamics of the mite's population
132 across locations was irregular with its peak at Kwimba in August and June but drastically
133 decreased to the lowest in July. This was also reported by [13] that high *M. tanajoa* densities
134 were proved to occur in an irregular pace. More so, drier conditions might have encouraged
135 the survival, perpetuation and distribution of cassava green mite. Conversely, in 2016 low
136 mite's population was observed suggesting the impacts of high rainfall on the pest [12].



146

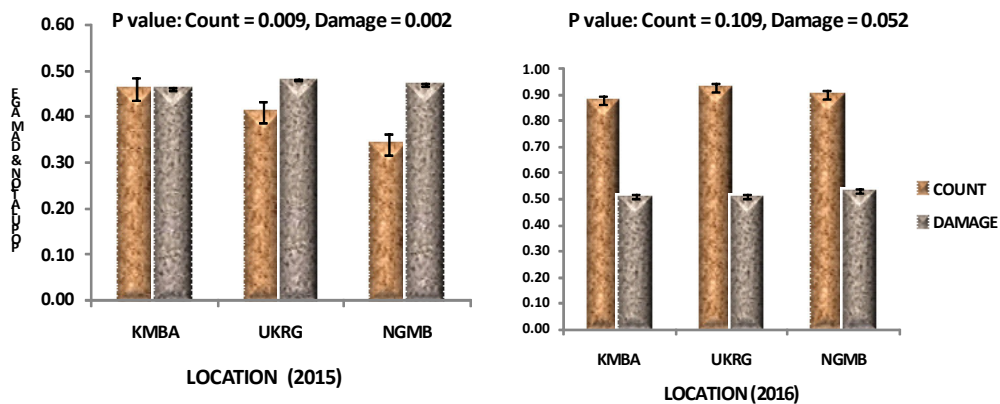
147 **Figure 2:** Map of Tanzania showing the study areas in Mwanza Region

148



SD_±: COUNT (2015) = 0.247, DAMAGE = 0.298COUNT (2016) = 0.157, DAMAGE = 0.094

Figure 3: Population and damage by *M. tanajoa* during 2015 and 2016 seasons.



SE_±: Count = 0.009 Damage = 0.002; SE_±: Count = 0.109 Damage = 0.052

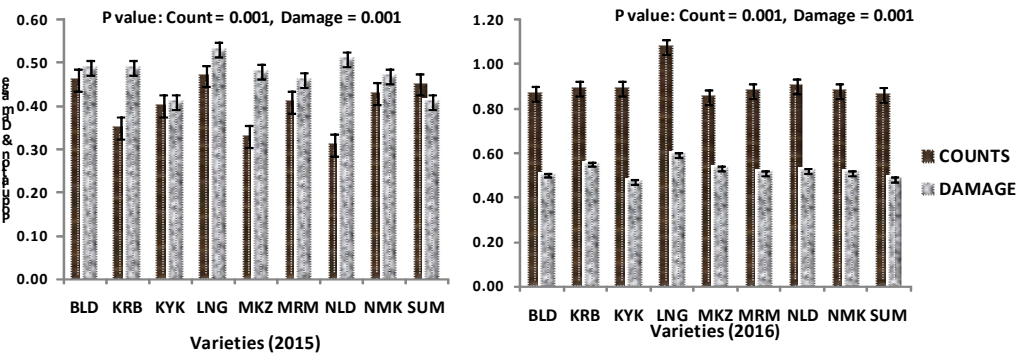
KEY: KMBA = Kwimba, UKRG = Ukiruguru, NGMB = N'gombe

Figure 4: *M. tanajoa* population and damage in three different locations in Mwanza region, Tanzania

The observed response of cassava varieties to *M. tanajoa* in 2015 and 2016 was shown (Fig. 5). There were significant ($P \leq 0.05$) differences in the population and damage caused by *M. tanajoa* in both years among the cassava varieties. Liongo Kwimba recorded the

166 highest mite population (0.47 in 2015 and 1.08 in 2016) and damage (0.53 in 2015 and 0.89
 167 in 2016) in the two seasons respectively while Naliendele (0.31 in 2015) recorded the lowest
 168 mite counts. However, Kyaka (0.41) and Suma (0.41) appeared to have the least damage in
 169 2015. Several authors [3, 14. 15] reported that limited availability of fresh plant growth
 170 (during the main part of the dry season) and heavy rainfall (in the middle of the rainy season)
 171 are the factors keeping the pest populations low. The higher population at Kwimba in 2015
 172 could be attributed to inadequate and irregular rainfall recorded in the study area due to the
 173 onset of rainfall but mite population decreased in subsequent months, especially at Ng'ombe
 174 and Ukiruguru at irregular intervals, which indicated that the dynamics of the mite's
 175 population across locations was irregular with its peak in August and June at Kwimba but
 176 drastically decreased to the lowest in July. This was also reported by [13] that high *M.*
 177 *tanjao* densities were proved to occur in an irregular space [3, 14. 15] Moreover, the
 178 damage was observed to fluctuate as reported by [9].

179



180

181 $SE_{\pm}$: Count = 0.025 Damage = 0.017 $SE_{\pm}$: Count = 0.033 Damage = 0.010

182 **Figure 5: Population dynamics and damage by *M. tanjao* on commercial and popular**
 183 **Cassava Varieties in Mwanza region, Tanzania.**

184

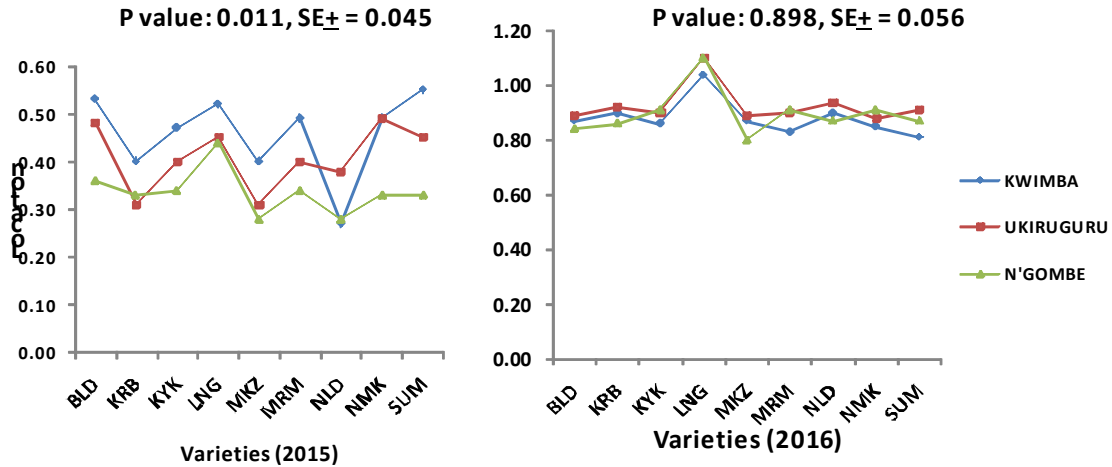


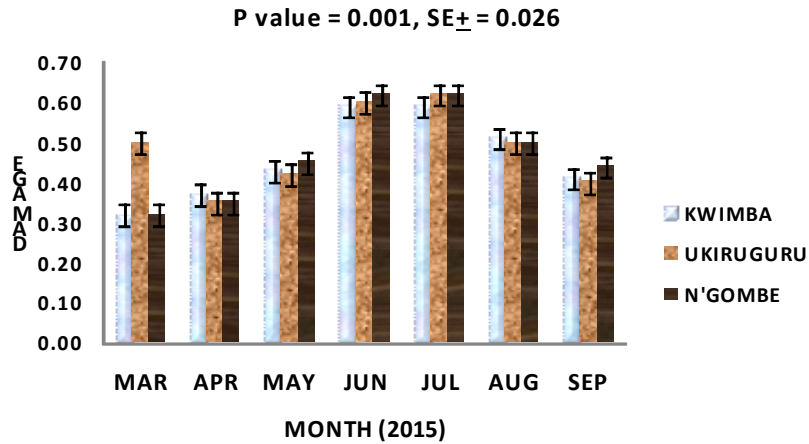
Figure 6: The variation in *M. tanajoa* population on tested cassava varieties among the three experimental sites in Mwanza

The responses of some cassava varieties to *M. tanajoa* population in three locations were found to be significant ($P \leq 0.05$) (Fig. 6). In 2015, Belinde (0.46) and Liongo Kwimba (0.47) varieties generally recorded higher number of mite's infestation while Mkombozi (0.40, 0.31 and 0.28) and Naliendele (0.27, 0.38 and 0.28) had the lowest number of *M. tanajoa* across the locations. Similarly in 2016, Liongo Kwimba (1.04, 1.10 and 1.10) recorded the highest number of mites in all the three locations followed by Naliendele (0.90, 0.94 and 0.87), Kyaka (0.86, 0.90 and 0.91) and Kiroba (0.90, 0.92 and 0.86). The lowest mite count was recorded on Suma (0.81), Namikonga (0.88) and Mkombozi (0.80) at the three study sites. This could be due to the inherent susceptibility or resistance/tolerant of the respective cassava varieties. Consequently, varietal differences as per the number and damage of *M. tanajoa* could not only be attributed to weather variables but also to the inherent characteristics of the genotype. Similar result was reported by [13, 16] that the variation in *M. tanajoa* population density among the genotype may be associated with factors inherent in the different genotypes. Moreover, in another research in Tanzania, [12] reported that generally, most of the cassava varieties found during the two diagnostic surveys were varied

204 which might affect the differences and similarities that exist across the zones in the two
205 years.

206 The effects of the interaction between cassava varieties and location on the damage by *M.*
207 *tanajoa* were not significant (Fig.7). However, in 2015, Liongo Kwimba (0.53, 0.53 and 0.54)
208 recorded higher damage across the locations followed by Naliendele (0.52, 0.49 and 0.51)
209 and Belinde (0.51, 0.49 and 0.50) with Suma (0.37, 0.46 and 0.39) having the lowest
210 damage compared to other varieties. Similarly, Liongo Kwimba (0.57, 0.61 and 0.60) and
211 Kiroba (0.54, 0.54 and 0.57) recorded higher damage in all the three locations in 2016 and
212 Kyaka (0.46, 0.46 and 0.48) was found to have the least damage among all other varieties
213 (Fig.8). In both years, the interaction effect between the tested varieties and locations on
214 root weight ha^{-1} was not significant (Fig.9). All the eight varieties were found to be
215 statistically similar. Moreover, among the other varieties, Kyaka performed better than the
216 seven other varieties. The lowest root weight was recorded by Liongo Kwimba in all the
217 three locations in the order Ukiruguru (9960.00kg-1), Kwimba (6560.00kg-1) and N'gombe
218 (12000.00kg-1) respectively. The damage on cassava varieties led to high loss of the
219 cassava leaves and subsequent reduction in the photosynthetic ability of the cassava and
220 the yield, especially on the susceptible varieties. This has been reported by researchers that
221 the damage has been equated to the loss of biomass and is an indicative loss of the leaf
222 photosynthetic area [17].

223

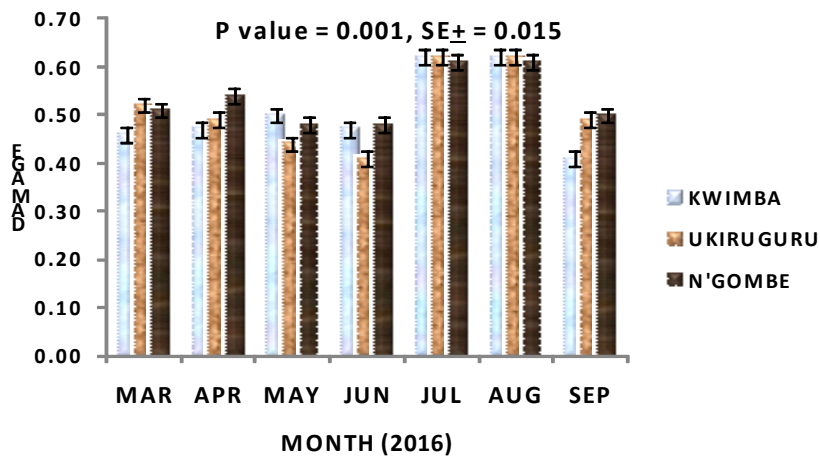


224

225 **Figure 7:** Interaction effects of cassava varieties and location on damage by *M.*

226 *tanajoa* in the Mwanza region, Tanzania in 2015

227



228

229 **Figure 8:** Interaction effects of cassava varieties and location on damage by *M.*

230 *tanajoa* in the Mwanza region, Tanzania in 2016

231

232

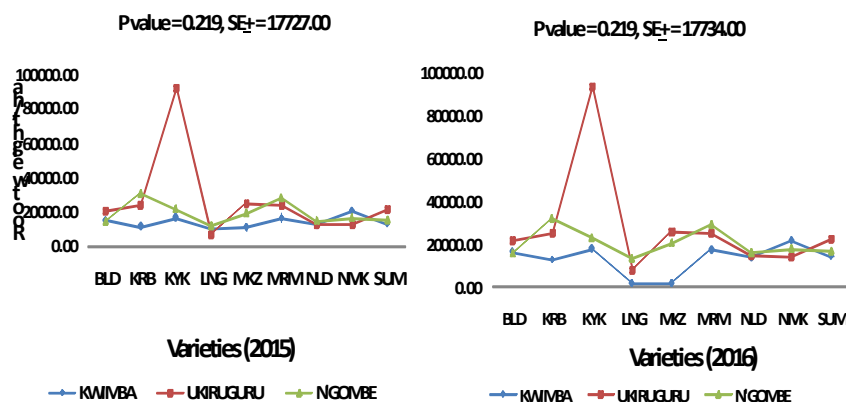


Figure 9: Interaction effects between variety and location on Average Root Weight (ha^{-1}) as influenced by *M. tanajoa* in Mwanza region, Tanzania.

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

Figures in parentheses are P values (significant at ≤ 0.005)

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

Table 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				2016DAMAGE		
Parameter	Beta (β Value)	SE $_{\pm}$	P Value	Beta (β 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 ≤ 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 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% and 34.3% variance to the number of *M. tanajoa* in (in 2015) and 2016.. Rainfall and minimum temperature were positively correlated to the mites' count while relative humidity and maximum temperature negatively related to *M. tanajoa* population of 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* population. However in 2016, there were negative relationship between rainfall and relative humidity while it was positive with the maximum and minimum

275 temperature. The fluctuations in damage caused by *M. tanajoa* within and across seasons
276 could be attributed to differences in weather variables over time and space as well as
277 inherent differences among the tested cassava varieties [16]. The difference in the number
278 and damage of the mites between years could be due to the higher temperatures recorded
279 in 2015 compared to 2016. Moreover, other factors such as differences in varieties and other
280 environmental variables especially rainfall and relative humidity probably contributed to the
281 perpetuation and damage caused by *M. tanajoa*. This explained that with an increase in unit
282 of the rainfall and relative humidity, there was decrease in the mites' counts in 2016 vice
283 versa in the case of maximum and minimum temperatures [12, 16].

284

285 Table 2 shows that the relationship among the weather variable was significant ($P \leq 0.05$).
286 Rainfall was found to be positively correlated to *M. tanajoa* damage in 2015 and negatively
287 in 2016. The relative humidity was negatively correlated to damage in both years while
288 maximum and minimum temperatures were negatively correlated in 2015 and positively in
289 2016. The fluctuations in damage caused by *M. tanajoa* within and across seasons could be
290 attributed to differences in weather variables over time and space as well as inherent
291 differences among the tested cassava varieties.

292 Generally, the population and damage were higher in 2016 compared to 2015 which could
293 be as a result of the higher amount of rainfall in 2015. Several researchers [12, 13, 14, 15,
294 16, 17 and 18] have reported a negative correlation between rainfall and number of mites.
295 This could be due to the fact that the population build-up of the pest started at the onset of
296 the dry season or end of the rainy season which is May, while July to August were the peak
297 periods and thus, the damage was subsequently higher. The damage led to high loss of the
298 cassava leaves and subsequent reduction in the photosynthetic ability of the cassava and
299 the yield, especially on the susceptible varieties. This has been reported by researchers that
300 the damage has been equated to the loss of biomass and is an indicative loss of the leaf
301 photosynthetic area [19].

302 **4. Conclusion**

303 The present studies have indicated that in both years, cassava varieties had responded
304 differently to *M. tanajoa* infestation at different locations and different times of the two
305 seasons in Lake Zone, Tanzania. Generally, the population and damage were higher in 2016
306 compared to 2015 season but followed similar trends across months and locations. The
307 regression of some weather variables against the population and damage inflicted by *M.*
308 *tanajoa* in both seasons predicted that all the weather variables tested have contributed either
309 positively or negatively to the survival, perpetuation of and damage by *M. tanajoa* in both
310 seasons. However, more researches should be carried out, especially breeding and
311 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? Experimental and Applied Acarology, 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. Report on TZNY Cassava. Cassava: Adding Value for Africa. Driving demand for Cassava in Tanzania: 2012; Draft Report. 61pp.
9. 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.
10. GenStat. Genstart Statistical Analysis System (2004).SAS User's Guide Statistics 2004 Edition. Statistical Analysis System Institute, Cary.
11. Eric, S. Inference Fundamentals, Virginia Tech. Fall. STAT 5034/CRN 96072, Printing services. 20013; 540-231-6701, 1425 S. Main Street. 356 pp.
12. Wudil, B. S.; Rwegasira, G. M.; Kudra, A. B. and Jeremiah, S. Spatial and Temporal Distribution of Cassava Green Mite, *Mononychellus tanajoa* Bondar (Acarina:

- 352 Tetranychidae) in Tanzania. Archives of Current Research International, 2017; 8(3): 1
353 -13.
- 354 13. Toko, M., Yaninek, J. S. and O'Neill, R. J. Response of *Mononychellus tanajoa*
355 (Acari: Tetranychidae) to cropping systems, cultivars, and pest interventions.
356 Environmental Entomology. 1996; 25: 237-249.
- 357 14. Onzo, A., Hanna, R. and Sabelis, M. W. Temporal and spatial dynamics of an exotic
358 predatory mite and its herbivorous mite prey on cassava in Benin, West Africa.
359 Environmental Entomology. 2005; 34: 866 – 874.
- 360 15. Hanna, R., Onzo, A. and Lingeman, R. Seasonal cycles and persistence of an
361 acarine predator-prey system on cassava in Africa. Population Ecology. 2005;
362 47:107-117.
- 363 16. Wudil B. S., Rwegasira, G. M., Kudra, A. B. and Jeremiah, S. Response of Some
364 Cassava Varieties to *Mononychellus tanajoa* Bondar. (Tetrachynidae: Acarina)
365 Infestation in the Lake Zone, Tanzania. 2016, 7(4): 1-9.
- 366 17. Akinlosotu, T. A. and Leuschner, K. Outbreaks of two new pests (*Mononychellus*
367 *tanajoa* and) in southern Nigeria. Tropical Pest Management, 1981; 27: 247-250.
- 368
- 369 18. Teodoro, A. V., Klein, A. M. and Tscharnkte, T. Temporally mediated responses of
370 the diversity of coffee mites to agro forestry management. Journal of Applied
371 Entomology, 2009a, 133: 659 - 665.
- 372
- 373 19. Teodoro, A., Klein, A. M. and Reis, P. R. Agro forestry management affects coffee
374 pests contingent on season and developmental stage. Agricultural and Forest
375 Entomology, 2009a 11: 295 - 300.
- 376

377