

Original Research Article

Environment and Weather 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 occurrence 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 one later in Kwimba districts respectively. Infestation with *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, Naliendele, Suma and Namikonga were comparatively the most susceptible. 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 yield and major diseases, but limited information exists on their response to the combined effect of *M. tanajoa* and the environment.

24 Cassava is a subsistence food to 200 million people in the African continent and in the Brazil
 25 serves as food for millions of poor people and plays an important role in the generation of
 26 employment and income, especially for small and medium producers [2]. Since its first
 27 occurrence in East Africa, the pest has expanded its distribution to the entire cassava
 28 growing belts, where it causes estimated yield losses ranging between 30-80 % [3].

29

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

37

38 Despite its importance and diverse use, cassava production in Tanzania (5462454 metric
 39 tons) and the rest of African countries (149479840 metric tons) is grossly low compared to
 40 world production statistics (256529314 metric tons) [7]. Several efforts have been made
 41 since mid-1980s by the Tanzanian National Root Crop Research Program and International
 42 organizations particularly the International Institute of Tropical Agriculture (IITA) to breed for
 43 new varieties with acceptable agronomic qualities mainly yield. From 1990s to date, the
 44 breeding efforts were diverted to management of viral diseases, the Cassava Mosaic
 45 Disease (CMD) and Cassava Brown Streak Disease (CBSD). Such efforts have greatly
 46 addressed disease problems although has not improved the production to great extent.
 47 Excerpts in production data from early 2000s to date indicates that the cassava production in
 48 Tanzania ranges from 45737 (in 2003) to 57.228 tons/ha (in 2012) which is far less than that

of India, 262,400 (in 2003) and 364,770 tons/ha (in 2012) in Asian countries [7]. As such many other biotic and abiotic production constraints remain to be addressed among which cassava green mite. It attacks the shoots/leaves and reduces photosynthetic rate or the root dry matter [8]. 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% [8].

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

2.0 Material and Methods

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 other five zones produce only 24.15% of the cassava root yield in the country [9]. Three different field trials were conducted in two consecutive years (2015 and 2016) to assess the environmental (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. Nine different cassava varieties (Naliendele, Kiroba, Meremeta, Belinde, Liongo Kwimba, Suma, Mkombozi, Kyaka and Namikonga) were planted at each location and these were

77 randomized into nine plots in a Split Plot Design with locations as main plots while varieties
 78 as sub plots and these were replicated three times making a total of twenty seven plots. The
 79 treatments were allocated to a plot size of 36m² with 1m path (boarder) between plots and
 80 2m between blocks, respectively. One stem cutting (30cm long) was planted at a spacing of
 81 1x1m within and between rows giving a total of 10000 plant population ha⁻¹ in a 1924m² plot.
 82 This was allowed under natural infestation by the mites.

83

84 **2.1 Population assessment of *M. tanajoa***

85 Cassava green mite population was monitored at monthly intervals starting at three months
 86 after planting i.e from March and ending in September, 2015 respectively. This was taken by
 87 the physical counting of the mites on the top fully open five leaves using a hand lens (Model
 88 No. YT1045/50mm). In each plot, eighteen cassava plants within a net plot were sampled
 89 randomly for assessment while leaving out the border rows to avoid border effects [4].

90 **2.2 Leaf damage assessment**

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

95

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 [11]. Treatment means were compared using the least
 99 significant difference (LSD) at 5% level of significance ($P \leq 0.05$). While all the numerical data
 100 with low counts or zero values were transformed into log y+1 [12]. Yield data were taken in
 101 kilograms and subjected into tons ha⁻¹. Regression analysis was run to predict the effect of
 102 some weather variables on the population and damage of *M. tanajoa*.

103

104 3. RESULTS AND DISCUSSION

105

106 Results in fig. 4.2 indicated that both the population and damage of cassava green mite in
 107 the two seasons (2015 and 2016) were significant ($P = .05$). Higher population and damage
 108 were recorded in 2016 compared to 2015. Moreover within the two seasons, the *M. tanajoa*
 109 population and damage were found to be significant ($P = .05$) in 2015 with Kwimba recording
 110 the highest mites' population; followed by Ukiruguru while Ng'ombe had the lowest
 111 population (Fig. 4.3). Conversely, Ukiruguru recorded the highest damage followed by
 112 N'gombe while Kwimba had the least damage. However, the population and damage by
 113 cassava green mite was generally higher in 2016 compared to 2015, despite the insignificant
 114 difference among the three locations. The damage by *M. tanajoa* was significantly different
 115 ($P = .05$) among the locations whereby the mites damage in Kwimba and Ukiruguru were
 116 statistically similar while N'gombe having the highest. A similar result by [13] revealed that a
 117 comparative analysis of *M. tanajoa* population among districts indicated Kwimba and
 118 Misungwi districts of the Lake Zone recorded the highest population compared to all other
 119 Zones in the country across the two seasons.

120

121 The difference in the number and damage of the mites between years could be due to the
 122 higher temperatures recorded in 2015 compared to 2016. Moreover, other factor such as
 123 differences in varieties and other environmental variables especially rainfall and relative
 124 humidity probably contributed to the perpetuation and damage by *M. tanajoa* [13]. The
 125 higher population at Kwimba in 2015 could be attributed to so many reasons as Kwimba is
 126 considered the driest among the locations, thus high mite density. Initially the mite
 127 population was first observed in March, when the sampling started and when the rainfall had
 128 declined. This could probably make it higher especially at Kwimba but decreased to a certain
 129 level in subsequent months, especially at Ng'ombe and Ukiruguru at irregular intervals. This
 130 indicated that the dynamics of the mite's population across locations was irregular with its
 131 peak at Kwimba in August and June but drastically decreased to the lowest in July. This was

132 also reported by [14] that high *M. tanajoa* densities were proved to occur in an irregular
133 pace. More so, drier conditions might have encouraged the survival, perpetuation and
134 distribution of cassava green mite. Conversely, in 2016 low mite's population was observed
135 suggesting the impacts of high rainfall on the pest [13].

136

137

138

139

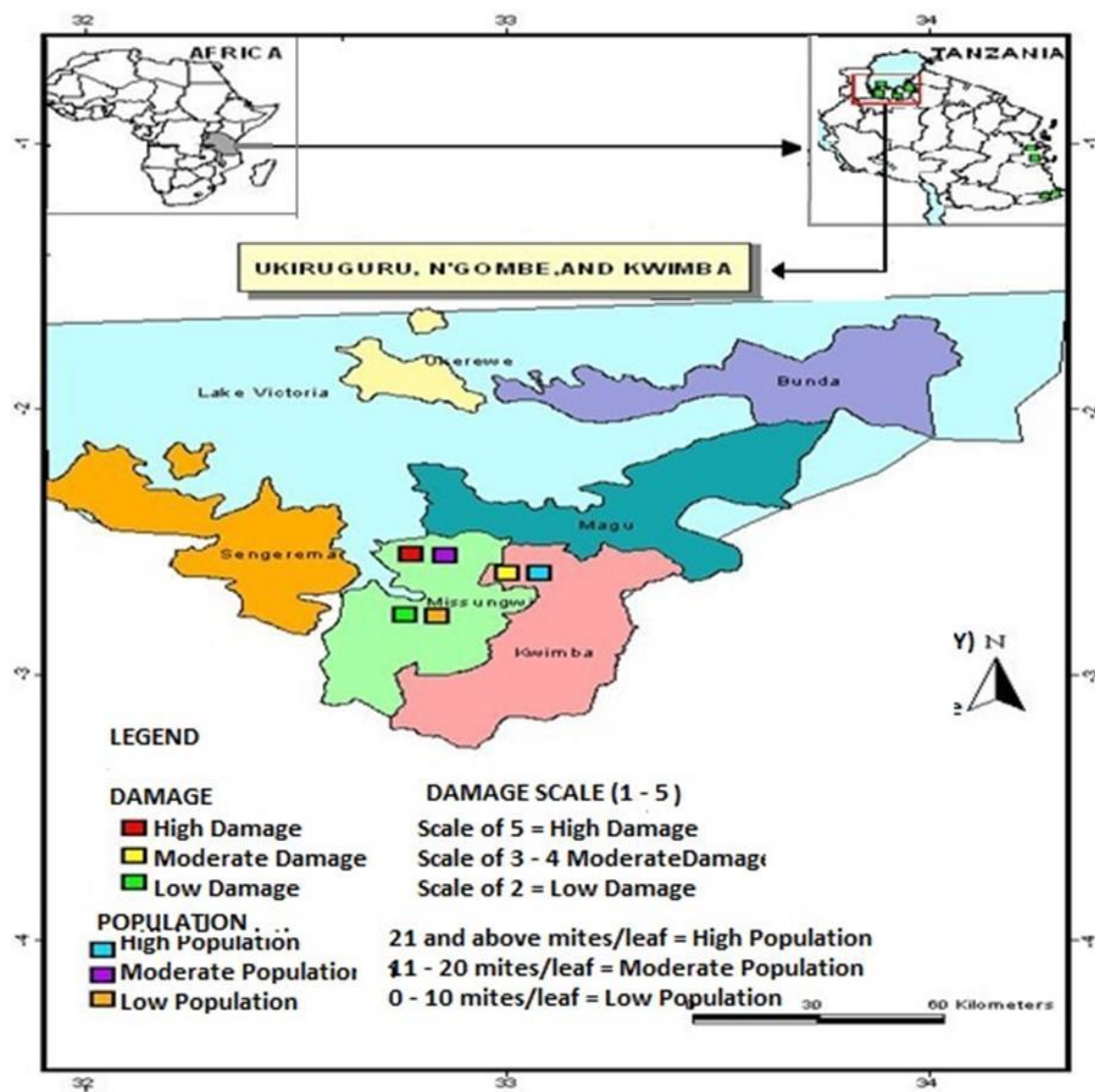
140

141

142

143

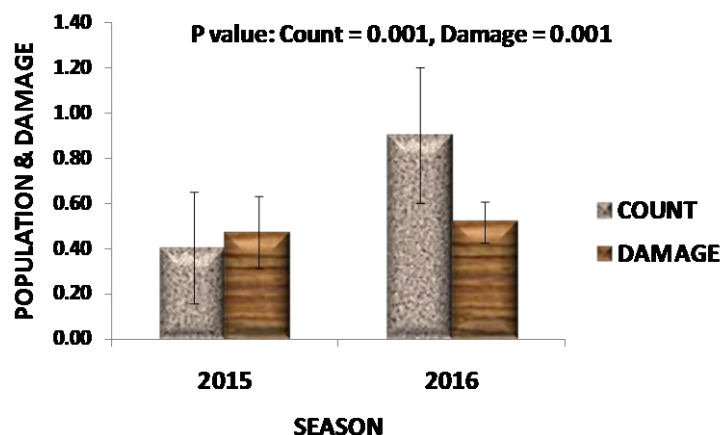
144



145

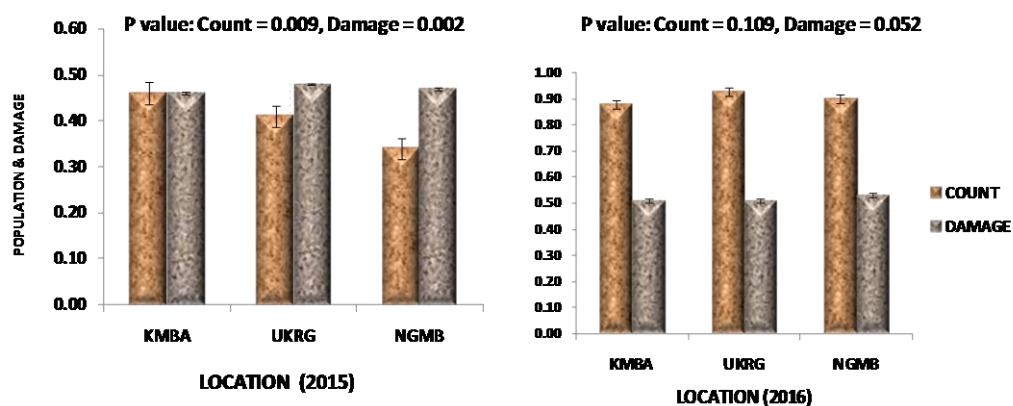
146 Figure 4.1: Map of Tanzania showing the study areas in Mwanza Region

147



SD_±: 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.



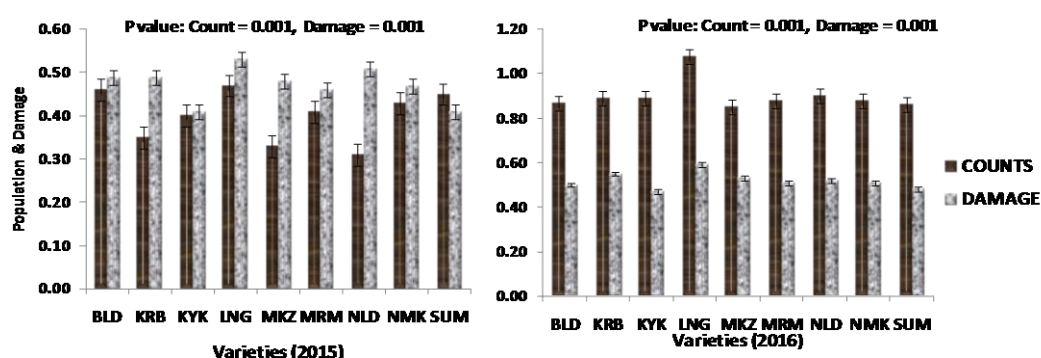
SE_±: Count = 0.009 Damage = 0.002; SE_±: Count = 0.109 Damage = 0.052

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

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

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

181



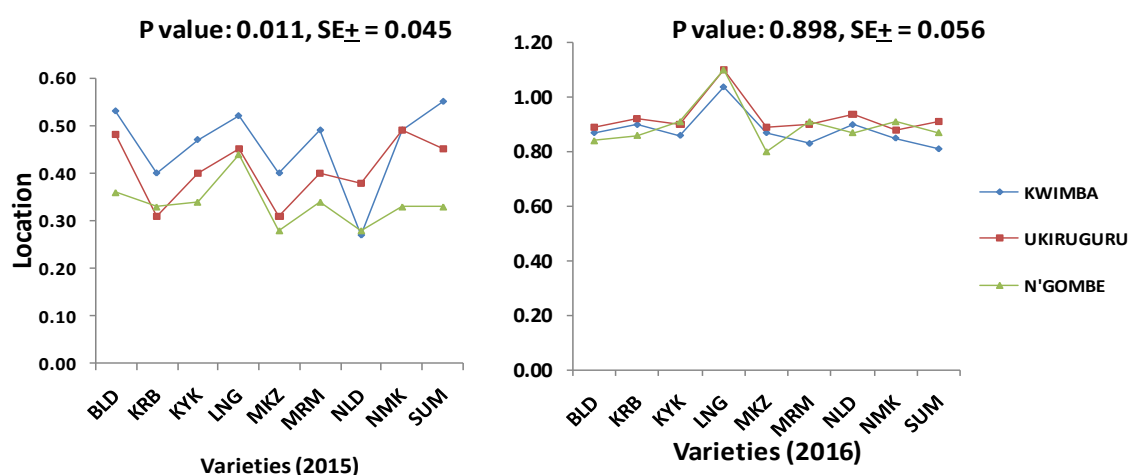
182

183 SE_{+} : Count = 0.025 Damage = 0.017

SE_{+} : Count = 0.033 Damage = 0.010

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

186



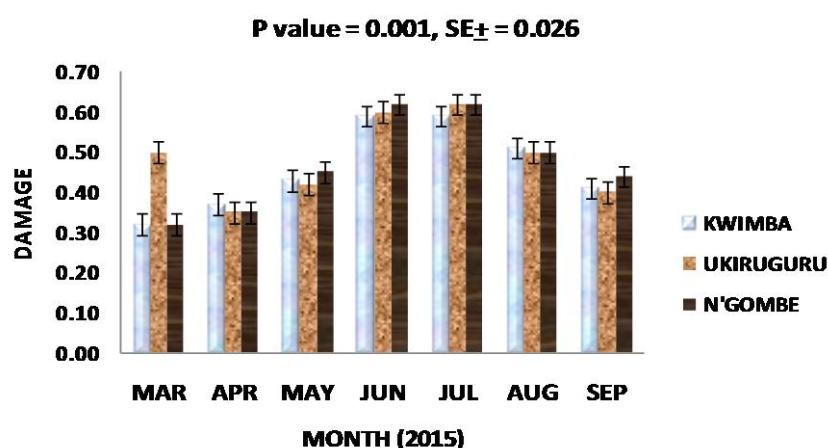
187

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

190

191 The performance of some cassava varieties to *M. tanajoa* population in three locations were
 192 found to be significant ($P \leq 0.05$) (Fig.4.5). In 2015, Belinde and Liongo Kwimba varieties
 193 generally recorded higher number of mites while Mkombozi and Naliendele had the lowest
 194 number of *M. tanajoa* across the locations. Similarly in 2016, Liongo Kwimba recorded the
 195 highest number of mites in all the three locations followed by Naliendele, Kyaka and Kiroba.
 196 The lowest mite count was recorded on Suma, Namikonga and Mkombozi at all the three
 197 study sites. This could be due to the inherent susceptibility or resistance/tolerant of the
 198 respective cassava varieties. Consequently, varietal differences as per the number and
 199 damage of *M. tanajoa* could not only be attributed to weather variables but also to the
 200 inherent characteristics of the genotype. Similar result was reported by [14, 17] that the
 201 variation in *M. tanajoa* population density among the genotype may be associated with
 202 factors inherent in the different genotypes. Moreover, in another research in Tanzania, [13]
 203 reported that generally, most of the cassava varieties found during the two diagnostic
 204 surveys were varied which might affect the differences and similarities that exist across the
 205 zones in the two years.

206 The effects of the interaction between cassava varieties and location on the damage by *M.*
 207 *tanajoa* were not significant (Fig.4.6). However, in 2015, Liongo Kwimba recorded higher
 208 damage across the locations followed by Naliendele and Belinde with Suma having the
 209 lowest damage compared to other varieties. Similarly, Liongo Kwimba and Kiroba recorded
 210 higher damage in all the three locations in 2016 and Kyaka was found to have the least
 211 damage among all other varieties (Fig.4.7). In both years, the interaction effect between the
 212 tested varieties and locations on root weight ha^{-1} was not significant (Fig.4.8). All the other
 213 eight varieties were found to be statistically similar. Moreover, among the other varieties,
 214 Meremeta performed better than other seven varieties. The lowest root weight was recorded
 215 by Liongo Kwimba in all the three locations in the order Ukiruguru, Kwimba and N'gombe
 216 respectively. The damage on cassava varieties led to high loss of the cassava leaves and
 217 subsequent reduction in the photosynthetic ability of the cassava and the yield, especially on
 218 the susceptible varieties. This has been reported by researchers that the damage has been
 219 equated to the loss of biomass and is an indicative loss of the leaf photosynthetic area [18].
 220



221

222 **Figure 4.6: Interaction effects of cassava varieties and location on damage by *M.***

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

224

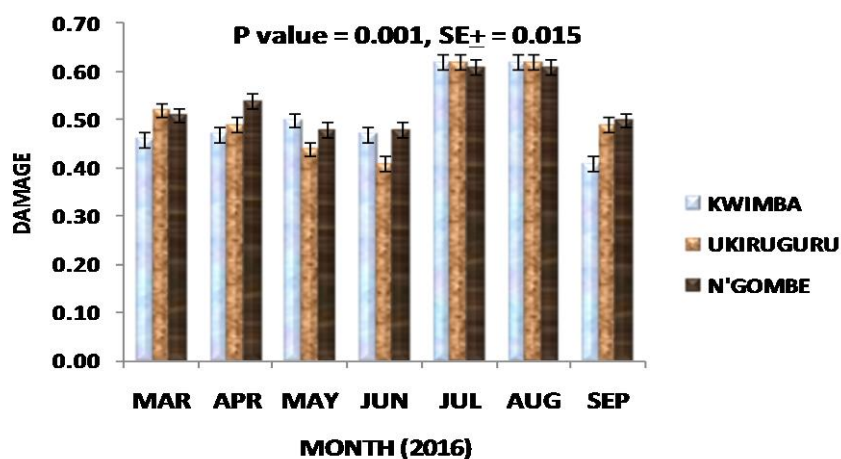


Figure 4.7: Interaction effects of cassava varieties and location on damage by *M. tanajoa* in the Mwanza region, Tanzania in 2016

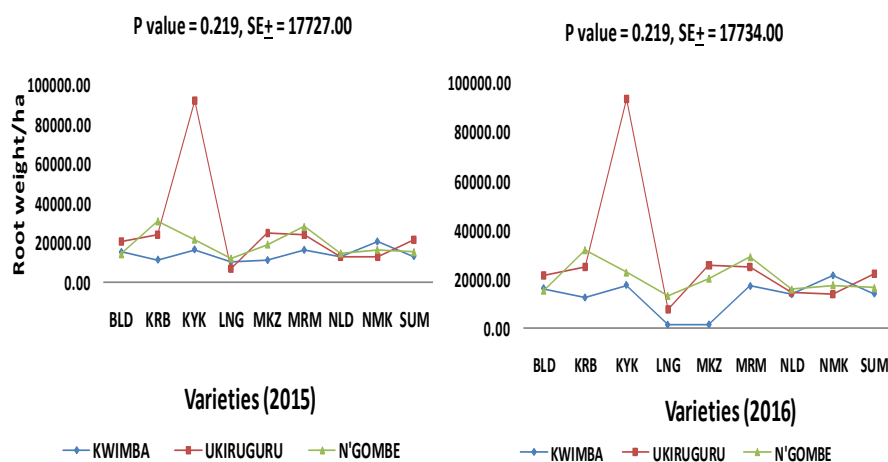


Figure 4.8: Interaction effects between variety and location on Average Root Weight (ha^{-1}) as influenced by *M. tanajoa* in Mwanza region, Tanzania.

236 **Table 4.1: Regression analysis of some weather variables against *M. tanajoa* count**
 237 **during 2015 and 2016 rainy and dry seasons in Mwanza region,**
 238 **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)**

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

240

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

243

244

245

246

247

248 **Table 4.2: Regression analysis of some weather variables against *M. tanajoa* damage**
 249 **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)**

250

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

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

254

255

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 (in 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 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 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 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 by *M. tanajoa*. This explained that with an increase in unit of the rainfall and relative humidity, there will be 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

283 that will negatively affects the mites count. This indicated that with increase in a unit in
284 rainfall in 2015 will subsequently increase mites' damage and vice versa in 2016.

285

286 Table 4.2 shows that the relationship among the weather variable was significant ($P \leq 0.05$).
287 Rainfall was found to be positively correlated to *M. tanajoa* damage in 2015 and negatively
288 in 2016. The relative humidity was negatively correlated to damage in both years while
289 maximum and minimum temperatures were negatively correlated in 2015 and positively in
290 2016. The fluctuations in damage by *M. tanajoa* within and across seasons could be
291 attributed to differences in weather variables over time and space as well as inherent
292 differences among the tested cassava varieties.

293

294 Generally, the population and damage were higher in 2016 compared to 2015 which could
295 be as a result of the higher amount of rainfall in 2015. Several researchers [13, 14, 15, 16,
296 17, 19 and 20] have reported a negative correlation between rainfall and number of mites.
297 This could be due to the fact that the population build-up of the pest started at the onset of
298 the dry season or closure of the rainy season which is May, while July to August were the
299 peak periods and thus, the damage was subsequently higher. The damage led to high loss
300 of the cassava leaves and subsequent reduction in the photosynthetic ability of the cassava
301 and the yield, especially on the susceptible varieties. This has been reported by researchers
302 that the damage has been equated to the loss of biomass and is an indicative loss of the leaf
303 photosynthetic area [18].

304 **4. Conclusion**

305 The present studies have indicated that in both years, cassava varieties had responded
306 differently to *M. tanajoa* at different locations and different times of the two seasons in Lake
307 Zone, Tanzania. Generally, the population and damage were higher in 2016 compared to
308 2015 season but followed similar trends across months and locations. The regression of

309 some weather variables against the population and damage by *M. tanajoa* in both seasons
310 predicted that all the weather variables tested have contributed either positively or negatively
311 to the survival, perpetuation of and damage by *M. tanajoa* in both seasons. However, more
312 researches should be carried out, especially breeding and molecular research to improve the
313 adapted locals especially Liongo Kwimba.

314 6.0 COMPETING INTERESTS

315

316 The Authors have declared that no competing interests exist.

317

318

319 7.0 REFERENCES

320

321 1. Zundel, C., Hanna, R., Scheidegger, U. and Nagel, P. Living at the Threshold:
 322 Where Does the Neotropical Phytoseiid Mite, Typhlodromalus aripo Survive the Dry
 323 Season? Exp Appl Acarol., 2007, 41:11 – 26.

324 2. Andre, R., Machi, F., de Cássia, N., Esteca, P., Bergamim Arthur, M. Adriani, G. and
 325 Arthur, V. A Review on Mononychellus tanajoa (Bondar, 1938) Pest of Cassava in
 326 Brazil. Australian Journal of Basic and Applied Sciences, 2014, 8(3): 342 – 348.

327 3. Yaninek, J. S., Moraes, G.J. and Markham, R.H. Handbook on the Cassava Green
 328 Mite (Mononychellus Tanajoa) in Africa: A Guide to Its Biology and Procedures for
 329 Implementing Classical Biological Control. 1989: IITA.pp140.

330 4. Évila, C. C., Adenir, V., Teodoro, A., Rêgo, S., Anilde, G., Maciel S. and Renato, S.
 331 Population structure and dynamics of the cassava green mite, Mononychellus
 332 tanajoa (Bondar) and the predator Euseius ho (DeLeon) (Acari: Tetranychidae,
 333 Phytoseiidae). Arthropods. 2012; 1(2): 55 - 62.

334 5. Nyijira, Z. M. Report of Investigation of Cassava mite, Mononychellus tanajoa
 335 (Bondar). Kawanda research Station, Kampala, Uganda, Unpublished report. 1972;
 336 14pp.

337 6. Msabaha, M. A. M., Ndibaz, R.E. and Nyango, A.K. Cassava Research Advances in
 338 Tanzania for the Period 1930 – 1988.Tanzania Agricultural Research Organisation,
 339 Ministry of Agriculture and Livestock Development, Tanzania. 1988; 25pp.

340 7. Food and Agricultural Organization. FAOSTAT database [http://www.fao.org] 2013;
 341 site visited on 12th March, 2014.

342 8. Moraes, G. J. and Flechtmann, C. H. W. (2008). Manual de Acarologia: acarologia
 343 básicae ácaros de plantas cultivadasno Brasil. Holos, Ribeirão Preto, Brazil.

344 9. Report on TZNY Cassava. Cassava: Adding Value for Africa. Driving demand for
 345 Cassava in Tanzania: 2012; Draft Report. 61pp.

346 10. Nukenine, E.N., Hassan, A.T., Dixon, A.G.O. and Fokunang, C.N. Population
 347 Dynamics of Cassava Green Mite, Mononychellus tanajoa (Bondar) (Acarina:
 348 Tetranychidae) as influenced by Varietal Resistance. Pakistan Journal of Biological
 349 Sciences. 2002; 5(2): 177 – 183.

350 11. GenStat, Genstart Statistical Analysis System (2004).SAS User's Guide Statistics
 351 2004 Edition. Statistical Analysis System Institute, Cary.

352 12. Eric, S. Inference Fundamentals, VirginiaTech. Fall. STAT 5034/CRN 96072,
 353 Printing services. 20013; 540-231-6701, 1425 S. Main Street. 356 pp.

- 354 13. Wudil, B. S.; Rwegasira, G. M.; Kudra, A. B. and Jeremiah, S. Spatial and Temporal
 355 Distribution of Cassava Green Mite, *Mononychellus tanajoa* Bonder (Acarina:
 356 Tetranychidae) in Tanzania. Archives of Current Research International. 2017; In
 357 press.

- 358 14. Toko, M., Yaninek, J. S. and O'Neill, R. J. Response of *Mononychellus tanajoa*
 359 (Acari: Tetranychidae) to cropping systems, cultivars, and pest interventions.
 360 Environmental Entomology. 1996; 25: 237-249.

- 361 15. Onzo, A., Hanna, R. and Sabelis, M. W. Temporal and spatial dynamics of an exotic
 362 predatory mite and its herbivorous mite prey on cassava in Benin, West Africa.
 363 Environmental Entomology. 2005; 34: 866 – 874.

- 364 16. Hanna, R., Onzo, A. and Lingeman, R. Seasonal cycles and persistence of an
 365 acarine predator-prey system on cassava in Africa. Population Ecology. 2005;
 366 47:107-117.

- 367 17. Wudil B. S., Rwegasira, G. M., Kudra, A. B. and Jeremiah, S. Response of Some
 368 Cassava Varieties to *Mononychellus tanajoa* Bondar. (Tetrachynidae: Acarina)
 369 Infestation in the Lake Zone, Tanzania. 2016, 7(4): 1-9.
 370

- 371 18. Akinlosotu, T.A. and Leuschner, K. Outbreaks of two new pests (*Mononychellus*
 372 *tanajoa* and *Phenacoccus manihoti*) in southern Nigeria. Tropical Pest Management,
 373 1981; 27: 247-250.

- 374 19. Teodoro, A. V., Klein, A. M. and Tscharntke, T. Temporally mediated responses of
 375 the diversity of coffee mites to agro forestry management. Journal of Applied
 376 Entomology, 2009a, 133: 659 - 665.
 377

- 378 20. Teodoro, A., Klein, A. M. and Reis, P. R. Agro forestry management affects coffee
 379 pests contingent on season and developmental stage. Agricultural and Forest
 380 Entomology, 2009a 11: 295 - 300.
 381

- 382