

Original Research Article

Varietal and Environmental Responses as Influenced by *Mononychellus tanajoa* Bondar (Tetranychidae: Acarina) in the Lake Zone, Tanzania

ABSTRACT

The study was aimed to determine the responses of 9 commercial and local cassava varieties to *M. tanajoa* and the environment in two different seasons (2014/2015, wet and dry). in the lake Zone. This was laid out in a Split plot design with varieties as sub plots and locations as main plots. Three field trials were conducted at three different locations, Ukiruguru (Latitude 020 43.156' S, Longitude 0330 01.431' E and elevation of 4000m above sea level) N'gombe (Latitude 020 45.743' S, Longitude 0330 01.838' E and elevation 3888m above sea level) and Kishiri (Latitude 020 48.694' S, Longitude 0330 22.161' E and elevation 4023m above sea level) villages of Kwimba and Misungwi districts of Mwanza respectively. In each location, the 9 varieties were planted and randomized into nine plots using Split plot Design with location as main and varieties as sub plots, these were replicated three times making a total of twenty seven plots. The treatments were allocated to a plot size of 36m² with 1m path (boarder) between plots and 2m between blocks. One stem cutting (30cm long) was planted at a spacing of 1x1m within and between rows giving a total of 10,000 plant population ha⁻¹. This was allowed under natural infestation by the mites. The results indicated that the mites population and damage generally varied significantly (P= 0.05) among varieties, sampling dates and locations. In general, Kwimba recorded the highest population number of *M. tanajoa* while Ukiruguru had the highest root yield and number. The study shows that Kyaka appeared to be tolerant/resistance to cassava green mite while Lioongo Kwimba, Naliendele, Suma and Namikonga were found to be most susceptible respectively. Therefore, cassava varietal resistance has a significant effect on the population dynamics and severity of *M. tanajoa* in the Lake Zone, Tanzania.

Keywords: Varietal, Environmental Responses, Dynamics and *M. tanajoa*

1. INTRODUCTION

Cassava (*Manihot esculenta* Crantz: Euphorbiaceae) also known as yuca (Spanish), mandioca (Portuguese), tapioca and manioc (French) is a tropical and subtropical short-lived perennial shrub originating from Latin America, most probably the Amazon region Pellet and El-Sharkawy, 1997 [1]. It is grown throughout the Tropics from wet equatorial forest to drier areas where annual rainfall is at least 500mm. The crop is grown in over 39 African countries, of which Nigeria, Democratic Republic of Congo, Ghana, Angola, Mozambique, United Republic of Tanzania, Uganda and Malawi are among the top twenty (20) producers in the world [2]. Throughout Africa, cassava is used as food (fresh, boiled or flour) and source of starch for industrial purposes. Cassava leaves are nutritious vegetables in some countries and can also be used as animal feed. Tanzania is the sixth producer of cassava in Africa and annual root production is estimated at 5,462,454 tons from 761,100 hectares [3]; [4] and [5].

Cassava green mite: *Mononychellus tanajoa* Bondar. (Acari: Tetranychidae) is the most important among pests that attack cassava in Tanzania [6] and [7]. *Mononychellus sp.* was first reported in the country in 1972 at Ukerewe Islands [7] and [8]. It attacks mainly shoots and leaves of cassava reducing both photosynthetic rate and root dry matter [7]. In the Lake

zone, the pest is more devastating with losses ranging from 20% to 80% tuber yield loss if left uncontrolled [10]. At present the mites have spread throughout the country, although at varied incidences among agro-ecological zones. It is not known that if such variations are related to environmental differences, varied response of cassava varieties that are commonly grown or the *M. tanajoa* species in Tanzania is genetically diverse.

Despite its importance and diverse use, cassava production in Tanzania (5,462,454 metric tons) and the rest of African countries (149, 479, 840 metric tons) is grossly low compared to world production statistics (256,529,314 metric tons). Several efforts have been made since mid1980s by the Tanzanian national root crop research program and international organizations particularly the International Institute of Tropical Agriculture (IITA) to breed for new varieties with acceptable agronomic qualities mainly yield. In 1990s to date, the breeding efforts were diverted to management of viral diseases, the Cassava mosaic disease (CMD) and cassava brown streak disease (CBSD). Such efforts have greatly addressed disease problems although has not improved the production to great extent. Excerpts in production data from early 2000s to date indicates that the cassava production in Tanzania ranges from 45,737 (in 2003) to 57,228 tons Hg/ha (in 2012) which is far less than that of India, 262,400 (in 2003) and 364,770 tons Hg/ha (in 2012) in Asian countries [2]. As such many other biotic and abiotic production constraints remains to be addressed among which Cassava green mite is important. Several improved and commercial cassava varieties have been bred and officially released in Tanzania targeting the yield and major diseases, but limited information exists on their response to *M. tanajoa*. Researches that are geared towards understanding the ecology and the importance of the pest are scarce. The dynamics of pest population across seasons has not been established in Tanzania. The genetic diversity in Tanzania and East Africa has never been explored. The current study aims at exploring the 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. MATERIAL AND METHODS

Lake Zone (020 45'S 320 45'E), Mwanza, Tanzania is the leading cassava producing zone that accounts for about 37.43% of the total cassava in the country, followed by the Southern zone, 26.50%; the Eastern zone, 12.36%; while other five zones produces only 24.15% of the cassava root yield in the country [11].

Three different field trials were conducted to determine the response of the commercial and local cassava varieties to *M. tanajoa* and the environment. The three sites, Ukiruguru (020 43.156'S, 0330 01.43'E and 4000m above sea level) Lake Zone Agricultural Research and Development Institute (LZARDI), N'gombe (020 45.743'S and 0330 01.838'E and 3888m above sea level) and Kishiri (020 48.694'S, and 0330 22.161'E and 4023m above sea level) villages of Kwimba and Misungwi districts respectively were selected for the experiments. Nine different cassava varieties (Naliendele, Kiroba, Meremeta, Belinde, Lingo, Suma, Mkombozi, Kyaka and Namikonga) were planted at each location and these were randomized into nine plots using Split Plot Design with locations as main 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 36m² 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 10,000 plant population ha⁻¹ in a 1, 924m² plot. This was allowed under natural infestation by the mites.

78 2.1 Parameters assessed

79 2.1.1. Population assessment of *M. tanajoa*

80 Cassava green mite population was monitored at monthly intervals after three (3) months of
81 planting i.e from March and ending in September, 2015 respectively. This was taken by the
82 physical counting of the mites from the top fully open five leaves using a hand lens (Model
83 No. YT1045/50mm). In each plot, eighteen (17) cassava plants were selected randomly and
84 in zig-zag pattern at least 1 cassava stand out from the habitat boundaries to avoid border
85 effects modified from [6].

86 2.1.2 Leaf damage and deformation assessment

87 The leaf damage was recorded using a scale of 1 to 5 (i.e. 1 means no obvious symptoms, 2
88 = less than 5% of leaf chlorosis, 3 = more than 5% but less than 50% of leaf chlorosis, 4 =
89 more than 50% of leaf chlorosis with significant reduction in leaf area and 5 = leaf is dead
90 and has dropped). Similarly, a scale of 1 to 5 (i.e 1 = no visible leaf deformation, 2 = Leaf
91 fairly deformed, 3 = moderately deformed leaf, 4 = more than 50% leaf deformation and 5 =
92 highly deformed and stunted/dead leaf) was used to assess the extent of the leaf
93 deformation as a result of the damage by the mites as reported by [12].

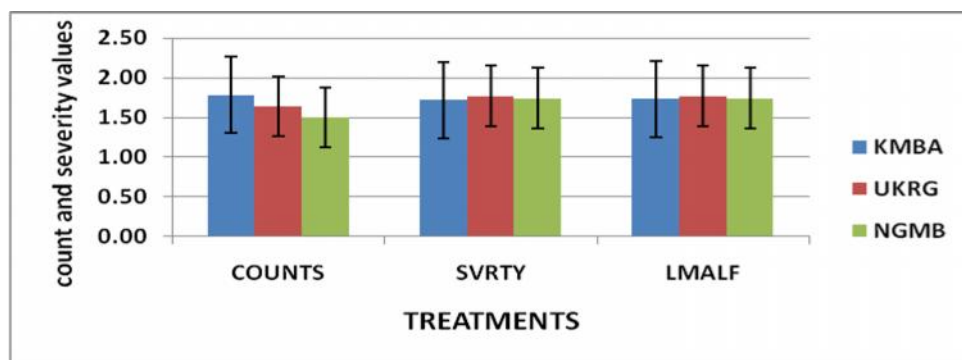
94 2.2 Statistical Analysis

95 All data collected were subjected to analysis of variance (ANOVA) in a Split plot design
96 using the SAS software [13]. Treatment means were compared using the Duncan's Multiple
97 Test (DMRT) at 5% level of significance ($P = .05$). While all the numerical data with low
98 counts or zero values were transformed to $\sqrt{n + 1}$. Yield data were taken in kilograms and
99 subjected into kg ha⁻¹.

100 101 3. RESULTS AND DISCUSSION

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103 Results in figure 1 shows the population number of cassava green mite and was found to be
104 significant ($P = .05$) with Kwimba recording the highest mites' population; this is followed by
105 Ukiruguru while N'gombe appeared to be the least. This could be attributed to so many
106 reasons as Kwimba is considered the driest among the locations, thus high mite density.
107 Initially the mite population was first observed in March, when the sampling started and
108 when the rainfall had declined. This probably made it higher especially at Kwimba but
109 decreased to a certain level in subsequent months especially N'gombe and Ukiruguru at
110 irregular intervals. This indicated that the dynamics of the mites across locations proved to
111 be irregular with its peak at Kwimba in August and June and this drastically decreased to the
112 lowest in July. This was also reported by [14] that high *M. tanajoa* densities were proved to
113 occur in an irregular space. Also several authors [15]; [16] and [17] reported that limited
114 availability of fresh plant growth (during the main part of the dry season) and heavy rainfall
115 (in the middle of the rainy season) are the factors keeping the pest populations low.
116 However, the severity and leaf deformation were observed using a scale of 1 – 5 as adopted
117 by [12] and there were no significant differences across the three locations.

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KEY: KMBA = Kwimba, UKRG = Ukiruguru, NGMB = N'gombe, SVRTY = Severity, LMALF = Leaf deformation

Figure 1. Responses of cassava varieties to population, severity and leaf deformation by *M. tanajoa* in the Lake Zone, Tanzania.

Figure 2 shows the mean number and severity of mite damage as observed from March to September 2015. There were significant ($P = .05$) differences among the mites counts across the months with its peak in August; this is followed by June with the least number in July. Seasonal changes in arthropods in the tropical areas have been related to several studies and these were due to the temporal variation in local environmental factors such as temperature, rainfall and humidity [18]. Cassava green mites are positively influenced by temperature and negatively influenced by rainfall [19] and [20]. Therefore, the mite population increases with an increase in temperature (above 300°C) and decreases with increase in rainfall. According to [24] the Jackknife tests reveal that environmental variables associated with temperature have more influence on potential distributions of *M. tanajoa* than any other variable. More so, as reported by [8] the mite population density and egg production are enhanced by dry periods, new leaf growth, and high quantities of chlorophyll; they decrease during and after rains. The above reasons could be attributed to the increase in the number of mites in June and August, a period with no rainfall in all the three locations. Nevertheless, the low mite population during the rainy season could be attributed to the splash action of the rain drops that washed the mites off the leaves and kill the mites. Dew droplets that might kill the mites, relative humidity and low temperatures that delayed mite development and growth also might be the contributing factors of low population number of mites. Similar findings were reported by [21].

Moreover, the mite severity and leaf deformation were found to be significant ($P = .05$). The highest damage and leaf deformation were observed in June and August while April recorded the least damage and leaf deformation. 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 of the rainy season which is May, while July to August were the peak periods and thus, the damage is higher. The visual damage led to high loss of the cassava leaves and subsequently 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 [22].

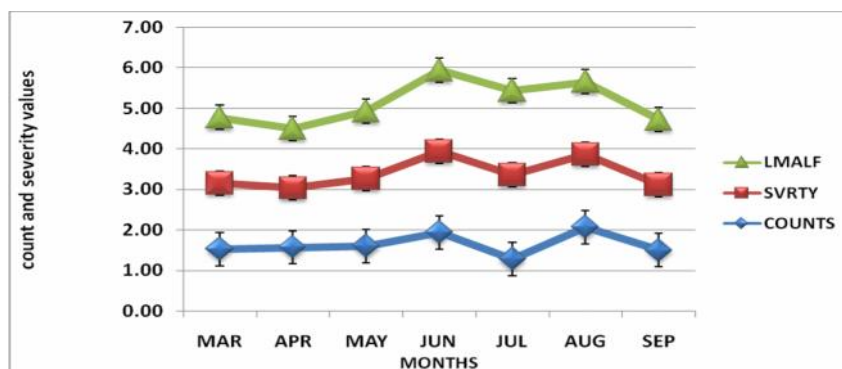


Figure 2. Population number, severity and leaf deformation caused by *M. tanajoa* as influenced by time interval (Months) in the Lake Zone, Tanzania.

Figure 3 shows the responses of some cassava varieties to *M. tanajoa* in the Lake zone, Tanzania. There were significant ($P = .05$) differences among the cassava varieties on the population, severity and leaf deformation caused by *M. tanajoa*. Liongo Kwimba recorded the highest number, damage and leaf deformation. This is followed by Suma, Namikonga and Belinde with Mkombozi recording the least mite counts, severity and leaf deformation. However, Mkombozi, Meremeta, Naliendele, Namikonga, Belinde and Kiroba were found to be significantly ($P = .05$) the same compared to other varieties as far crop damage. Similarly, Belinde, Kiroba, Mkombozi, Meremeta and Naliendele were also significantly ($P = .05$) the same in leaf deformation. Liongo Kwimba was found to be the most susceptible among all other varieties while Kyaka proved to be resistant to the pest in the study areas. This could be attributed to their inherent resistant/tolerance and/or susceptibility to the mites' damage. Similar result was reported by [13] that the variation in *M. tanajoa* population density among the genotype may be associated with factors inherent in the different genotypes. The varietal differences might existed for the population number and damage of *M. tanajoa*, with the resistant variety, Kyaka having an overall higher yield than the other susceptible varieties regardless of weather conditions, therefore varietal differences in the population and damage of *M. tanajoa* could not be attributed to weather variables.

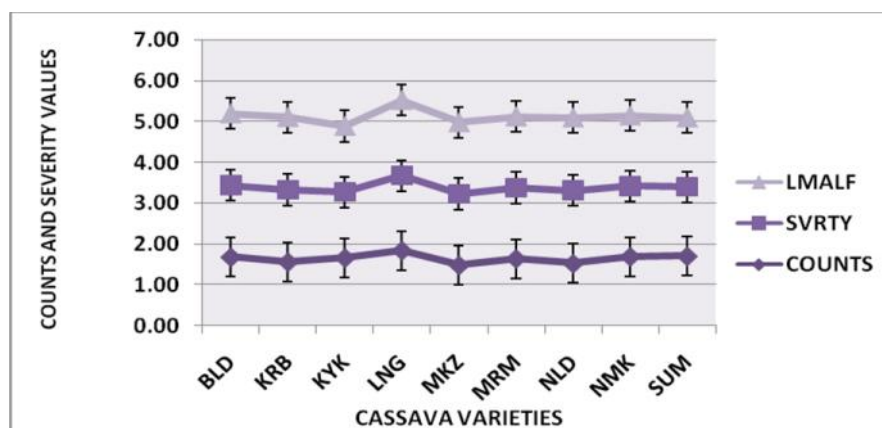
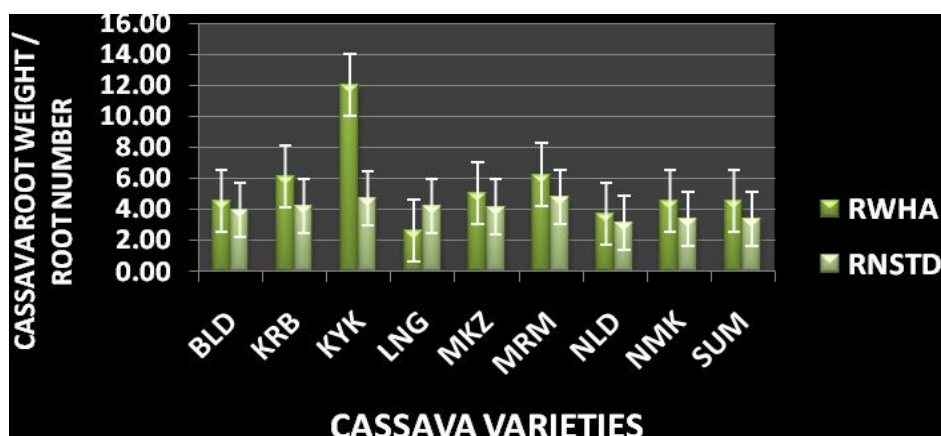


Figure 3. Performance of some Cassava Varieties as influenced by *M. tanajoa* Severity and leaf deformation and counts in Lake Zone, Tanzania.

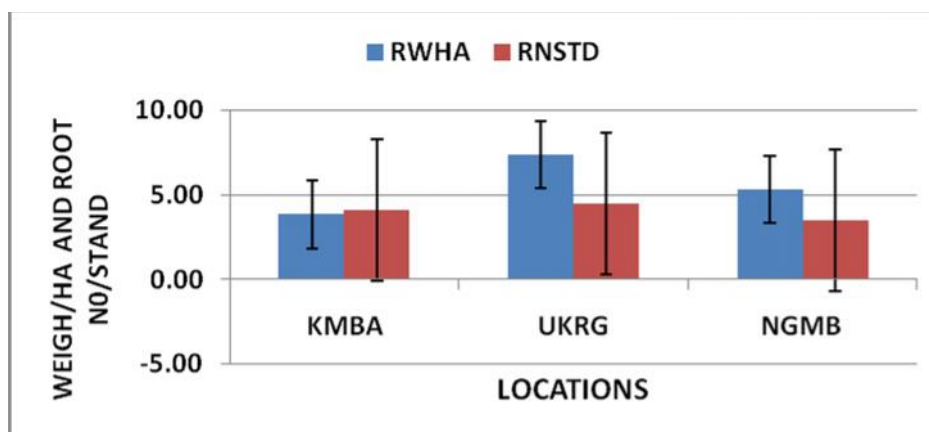
Figure 4 shows the average root weight (kg^{-1}) of cassava varieties as influenced by *M. tanajoa*. There was a significant ($P = .05$) difference among the cassava varieties tested, Kyaka recorded the highest ($12,010\text{kg}^{-1}$) root weight compared to all other varieties while all other eight varieties were statistically similar, however Liongo Kwimba proved to be inferior among all varieties ($2,641\text{kg}^{-1}$). More so, there was significant ($P = .05$) difference among the cassava varieties as affected by the number of roots whereby Meremeta and Kyaka were found to produce the highest number of roots, followed by Kiroba, Liongo Kwimba, Mkombozi and Belinde. While Suma, Namikonga and Naliendele were statistically ($P = .05$) the same and proved to be inferior with Naliendele recording the least root number. This indicated that the *M. tanajoa* population and damage have influence on different cassava varieties in the study areas [12]. Among the nine varieties, Kyaka proved to be the resistant to the mite as it recorded the highest yield irrespective of the attack by the mite. The pest can attack cassava and may lead yield reduction of about 21, 25 and 53% during a 3, 4 and 6 months attack i.e 73% for susceptible varieties and 15% for the resistant varieties [25]. *M. tanajoa* severely make damage to cassava up to an estimate of 80% throughout the African continent [23]; [15]. Similarly, the potential for yield loss or reduction by these pests is greater than the cyclical pests like hornworms which cause sporadic defoliation [25].



Key: BLD = Belinde, KRB = Kiroba, KYK = Kyaka, LNG = Liongo Kwimba, MKZ = Mkombozi, MRM = Meremeta, NLD = Naliendele, NMK = Namikonga, SUM = Suma

Figure 4 The root weight (Yield) and root number of nine cassava varieties in the Lake zone Tanzania

Figure 5 indicated that the cassava yield performance by location significantly ($P = .05$) differed among all the three locations with Ukiruguru having the highest number per stand (4.44) and root weight (7342kg^{-1}) followed by N'gombe (5298kg^{-1}) and lastly Kwimba ($3,833\text{kg}^{-1}$). However, Kwimba (4.06) recorded the higher root number after Ukiruguru and N'gombe (3.51) appeared to be the least. Based on the locations of the study, Ukiruguru recorded the highest cassava root weight and number which might probably be due to the differences in the soil nutrients and type as well as other environmental factors especially diseases.



Key: RWHA = Root Weight/Ha, RNSTD = Root Number/Stand

Figure 5. Cassava root weight (ha-1) and root number per stand as influenced by the three locations in the lake Zone, Tanzania.

The interaction effect between varieties and location on root weight ha^{-1} was significant ($P = .05$), Kyaka produced heaviest root weight at Ukiruguru compared to all other cassava varieties in the other locations (Figure 6). all the other eight varieties were found to be statistically similar. Moreover, among the other varieties, Kiroba performed better then followed by Meremeta although similar, but they produced heavier roots than the other varieties especially at N'gombe. The least root weight was recorded by Liongo Kwimba in all the three locations in the order Ukiruguru, N'gombe and Kwimba respectively. This indicated that although Liong Kwimba is the most common varieties planted in the study areas, it is highly susceptible to *M. tanajoa*.

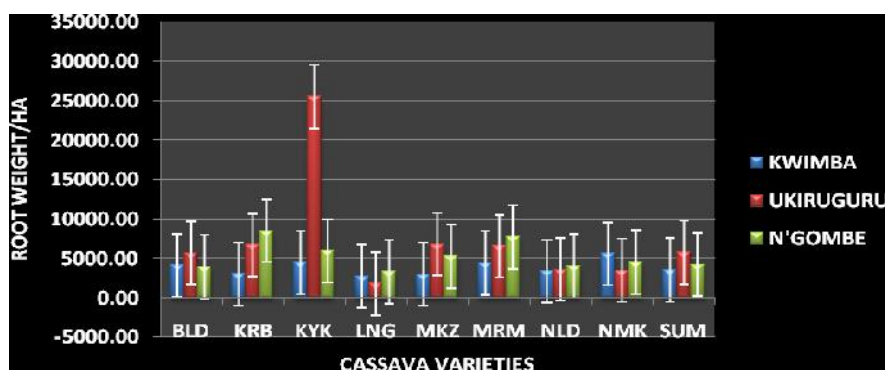


Figure 6. Interaction effects between varieties and locations on Average Root Weight (ha^{-1}) as influenced by *M. tanajoa* in the Lake zone, Tanzania.

4. CONCLUSION

The study had indicated that cassava varietal resistance has a significant effect on the population dynamics and severity of *M. tanajoa* in the Lake Zone, Tanzania. The mites' population, severity and leaf deformation were highest in June and August; these have been fluctuating among varieties over time. Among the three locations, Ukiruguru having the highest root number per stand (4.44) and root weight (7342kg h^{-1}) followed by N'gombe (5298kg^{-1}). More so, Kyaka recorded the highest root weight and root number among all the nine varieties with Liongo Kwimba appeared to be the least. Farmers should be made aware of the resistant/tolerance of Kyaka while Liongo Kwimba be improved as it is common local variety in the study area. However, more researches should be carried out especially breeding and molecular research to improve the adapted locals especially Liongo Kwimba.

REFERENCES

1. Pellet, C. and El-Sharkawy, G. (1997). Cassava Varietal Responses to Fertilization. Growth Dynamics and Implications for Cropping Sustainability. Research Article. Centro Internacional de Agricultura tropical (CIAT). 56pp.
2. Food and Agricultural Organization (2013). FAOSTART database accessed on the 10th – 12th March, 2014.
3. Food and Agricultural Organization (1998). Global Cassava Production and Consumption. FAO/GIEWS – Food Outlook No.5. 92pp.
4. Nweke, F.I.; Kapinga, R.E.; Dixon, A.G.O.; Ugwu, B. G.; Ajobo, O. and Asadu, C.I. A. (1998). Production prospects for cassava in Tanzania. *COSCA working paper No. 16. Collaborative study of cassava in Africa*. IITA, Ibadan, Nigeria. 175pp.
5. Kapinga, R.; Mafuru, J.; Simon, J.; Rwiza, E.; Kamala, R.; Mashamba, F. and Mlingi, N. (2005). Status of Cassava in Tanzania: Implication for the future Research and Development. In: A review of Cassava in Africa with country case studies in Nigeria, Ghana, the United Republic of Tanzania, Uganda and Benin. Proceedings of the validation forum on the global cassava development strategy. Volume 2. International Fund for Agricultural Development, Food and Agricultural Organisation of the United Nations, Rome. 170 – 254pp.

- 285 6. Évila C. Costa, Adenir V. Teodoro, Adriano S. Rêgo, Anilde G.S. Maciel and Renato
286 Sarmiento (2012). Population structure and dynamics of the cassava green mite
287 *Mononychellus tanajoa* (Bondar) and the predator *Euseius* ho (DeLeon) (Acari:
288 Tetranychidae, Phytoseiidae). *Arthropods*. 1(2): 55 - 62.
- 289
- 290 7. Nyiira, Z. M. (1972). Report of Investigation of Cassava mite, *Mononychellus tanajoa*
291 (Bondar). Kawanda research Station, Kampala, Uganda, Unpublished report, 14pp.
- 292
- 293 8. Msabaha, M. A. M., Ndibaz, R.E. and Nyango, A.K. (1988). Cassava Research
294 Advances in Tanzania for the period 1930 – 1988.tanzania Agricultural Research
295 Organisation, Ministry of Agriculture and Livestock Development, Tanzania. 25pp.
- 296
- 297 9. Moraes G. J. and Flechtmann C. H. W. (2008). Manual de Acarologia: acarologia
298 básicae ácaros de plantas cultivadas no Brasil. Holos, Ribeirão Preto, Brazil.
- 299
- 300 10. Anon, (1999). Plant Protection Annual report 1999. Ministry of Agriculture &
301 Cooperatives Tanzania.
- 302
- 303 11. Report on TZNY Cassava (2012). Cassava: Adding Value for Africa. Driving demand for
304 Cassava in Tanzania: Draft Report. 61pp.
- 305
- 306 12. Nukenine, E.N., Hassan A.T., Dixon, A.G.O. and Fokunang, C.N. (2002). Population
307 Dynamics of Cassava Green Mite, *Mononychellus tanajoa* (Bondar) (Acarina:
308 Tetranychidae) as influenced by Varietal Resistance. *Pakistan Journal of Biological*
309 *Sciences*. 5(2): 177 – 183.
- 310
- 311 13. SAS Software (1993). SAS Companion for Microsoft windows environment, version 6,
312 1st ed, SAs Institute, Cary, north Carolina, U.S.A.
- 313
- 314 14. Toko M, Yaninek J S, O'Neill R J (1996) Response of *Mononychellus tanajoa* (Acari:
315 Tetranychidae) to cropping systems, cultivars, and pest interventions. *Environmental*
316 *Entomology* 25:237-249

- 317 15. Yaninek, J.S., Moraes, G.J., and Markham, R.H. (1989). Handbook on the cassava
318 green mite (*Mononychellus tanajoa*) in Africa: a guide to its biology and procedures for
319 implementing classical biological control. IITA. Pp140.
- 320
- 321 16. Onzo A, Hanna R, and Sabelis MW, (2005). Temporal and spatial dynamics of an exotic
322 predatory mite and its herbivorous mite prey on cassava in Benin, West Africa.
323 *Environmental Entomology*. 34: 866 – 874.
- 324
- 325 17. Hanna, R., Onzo A, and Lingeman R, (2005). Seasonal cycles and persistence of an
326 acarine predator-prey system on cassava in Africa. *Population Ecology*. 47:107-117.
- 327
- 328 18. Klein, A. M., Stefan-Dewenter I, Buchori D, (2002). Effects of land-use intensity in
329 tropical agroforestry systems on coffee flower visiting and trap nesting bees and wasps.
330 *Conservation Biology*. 16: 1003–1014.
- 331
- 332 19. Gotoh, T. Suwa A., Kitashima Y, et al. 2004. Developmental and reproductive
333 performance of *Tetranychus pueraricola* Ehara and Gotoh (Acari: Tetranychidae) at four
334 constant temperatures. *Applied Entomology and Zoology*. **39**: 675 682.
- 335
- 336 20. Teodoro, A. V, Klein AM, and Tscharnkte T. (2008). Environmentally mediated coffee
337 pest densities in relation to agroforestry management, using hierarchical partitioning
338 analyses. *Agriculture, Ecosystems and Environment*. 125: 120-126
- 339
- 340 21. Yeninek, J.S., H. R. Herren and A. P. Gutierrez (1997). The Biological basis for the
341 seasonal outbreaks of cassava green mites in Africa. *Ins. Sci. Appl.* **8**: 861 – 865
- 342
- 343 22. Mutisya D.L, E.I Banhawy, E.M, Khamala C.P.M, Kariuki C.W. and Miano D.W. (2014).
344 Determination of Damage Threshold of Cassava Green Mite (Acari:Tetranychidae) on
345 Different Cassava Varieties. *Journal of Plant and Pest Science*. **1(2)**: 79 – 86.

346

347 23. Akinlosotu, T.A. and K. Leuschner, 1981. Outbreaks of two new pests (*Mononychellus*
348 *tanajoa* and *Phenacoccus manihoti*) in southern Nigeria. *Tropical Pest Management*, 27:
349 247-250.

350

351 24. Lu, H., N.M. Qingfe, Q. Chen, F. Lu and X. Xu, (2012). Potential geographic distribution
352 of the cassava green mite *Mononychellus tanajoa* in Hainan, China. *African Journal of*
353 *Agricultural Research*. 7: 1206-1213.

354

355 25. Bellotti, A.C. (2002). Pests and Diseases management project, Centro Internacional de
356 Agricultura Tropical (CIAT), A. A.6713, Cali, Columbia.