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Response of Some Cassava Varieties to *Mononychellus tanajoa* Bondar. (Tetrachynidae: Acarina) Infestation in the Lake Zone, Tanzania

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Authors' contributions

This work was carried out in collaboration between all authors. Author BSW design the study, wrote the protocol and the first draft of the manuscript. Author GMR made conceptual contributions, corrections and objective criticisms; he was assisted by author ABK. While author SKJ coordinated the field work with close supervision. All authors read and approved the final manuscript.

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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 4000 m above sea level) N'gombe (Latitude 020 45.743' S, Longitude 0330 01.838' E and elevation 3888 m above sea level) and Kishiri (Latitude 020 48.694' S, Longitude 0330 22.161' E and elevation 4023 m above sea level) villages of Kwimba and Misungwi districts of Mwanza, respectively. These were replicated three times making a total of twenty seven plots. The treatments were allocated to a plot size of 36 m^2 with 1 m path (boarder)

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between plots and 2 m between blocks. One stem cutting (30 cm long) was planted at a spacing of 1x1 m 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/resistant to cassava green mite while Liongo 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 damage of *M. tanajoa* in the Lake Zone, Tanzania.

Keywords: Varietal; cassava; population; 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 [1]. It is grown throughout the Tropics from wet equatorial forest to drier areas where annual rainfall is at least 500 mm. 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 [3-5].

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 [9]. 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 mid 1980s 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. From 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/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 [2]. As such many other biotic and abiotic production constraints remains to be addressed among which cassava green mite is important. It attacks the shoots/leaves and reduces photosynthetic rate or the root dry matter [10]. 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% [10].

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 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. MATERIALS 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 produce 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, Liongo Kwimba, 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 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 36 m^2 with 1 m path (boarder) between plots and 2 m between blocks, respectively. One stem cutting (30 cm long) was planted at a spacing of 1x1 m within and between rows giving a total of 10,000 plant population ha^{-1} in a 1, 924 m^2 plot. This was allowed under natural infestation by the mites.

2.1 Parameters Assessed

2.1.1 Population assessment of *M. tanajoa*

Cassava green mite population was monitored at monthly intervals after three (3) months of planting i.e from March and ending in September, 2015 respectively. This was taken by the physical counting of the mites from the top fully open five leaves using a hand lens (Model No. YT1045/50 mm). In each plot, eighteen (18) cassava plants were selected randomly and leaving 1 cassava stand out from the habitat boundaries to avoid border effects modified from [6].

2.1.2 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 [12].

2.2 Statistical Analysis

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

3. RESULTS AND DISCUSSION

Results in Fig. 1 show the population number of cassava green mite and was found to be significant (P = .05) with Kwimba recording the highest mites' population; this is followed by Ukiruguru while N'gombe appeared to be the lowest. This could be attributed to so many reasons as Kwimba is considered the driest among the locations, thus high mite density. Initially the mite population was first observed in March, when the sampling started and when the rainfall had declined. This probably made it higher especially at Kwimba but decreased to a certain level in subsequent months, especially N'gombe and Ukiruguru at irregular intervals. This indicated that the dynamics of the mites across locations proved to be irregular with its peak at Kwimba in August and June and this 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. Also several authors [15-17] 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. However, the damage was observed using a scale of 1 – 5 as adopted by [12] and there were no significant differences across the three locations.

Fig. 2 shows the mean number and severity of mite's 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 lowest 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 30℃) and decreases with an increase in rainfall. According to [21] 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

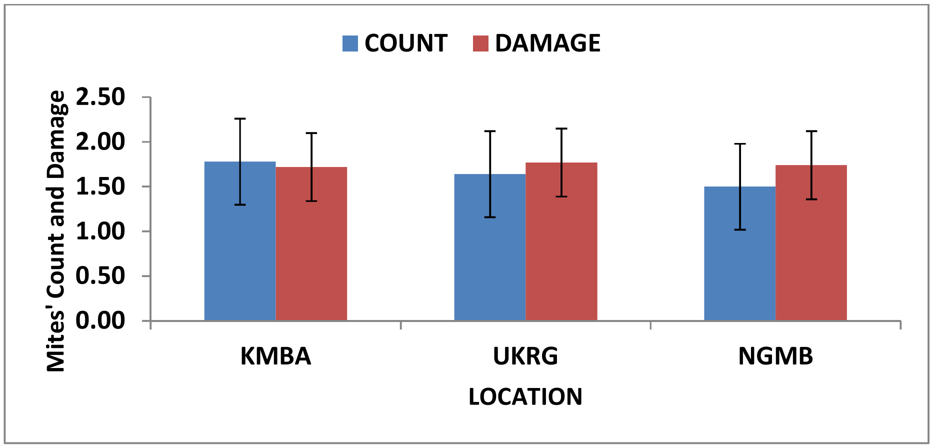

Fig. 1. Responses of cassava varieties to population and damage by *M. tanajoa* in the Lake Zone, Tanzania
KEY: *KMBA = Kwimba, UKRG = Ukiruguru, NGMB = N'gombe*
SE±: *COUNT = 0.48; DAMAGE = 0.38*

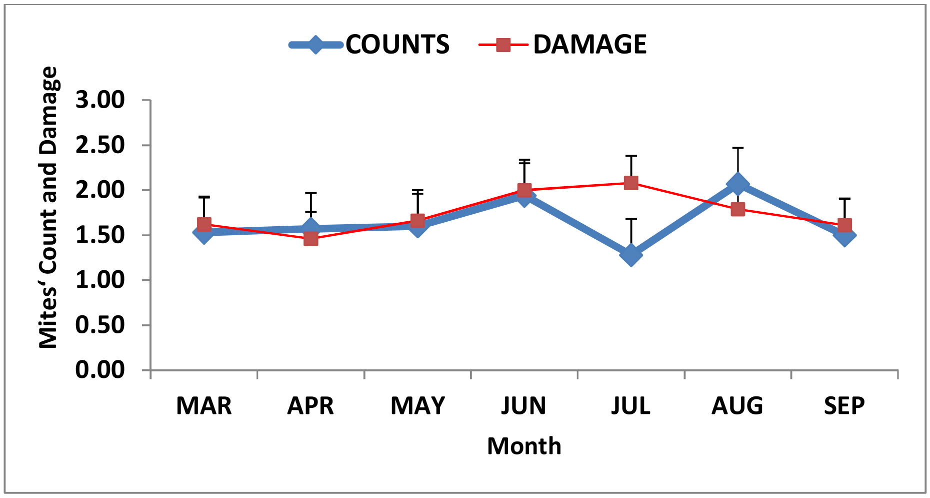

Fig. 2. Population number and damage caused by *M. tanajoa* as influenced by time interval (Months) in the Lake Zone, Tanzania
SE±: COUNT= 0.41; DAMAGE= 0.30

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 [22].

Moreover, the mite damage was found to be significant *(P = .05)*. The highest damage was observed in June and August while April recorded the least damage. 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 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 of loss of the leaf photosynthetic area [23].

Fig. 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 and damage caused by *M. tanajoa*. Liongo Kwimba recorded the highest number, and damage. This is followed by Suma, Namikonga and Belinde with Mkombozi recording the lowest mite counts and damage. However, Mkombozi, Meremeta, Naliendele, Namikonga, Belinde and Kiroba were found to be not significant compared to other varieties as far crop damage. 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 resistance/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 exist 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 only be attributed to weather variables.

Fig. 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 (12,010kg^{-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 (2,641kg^{-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 lowest

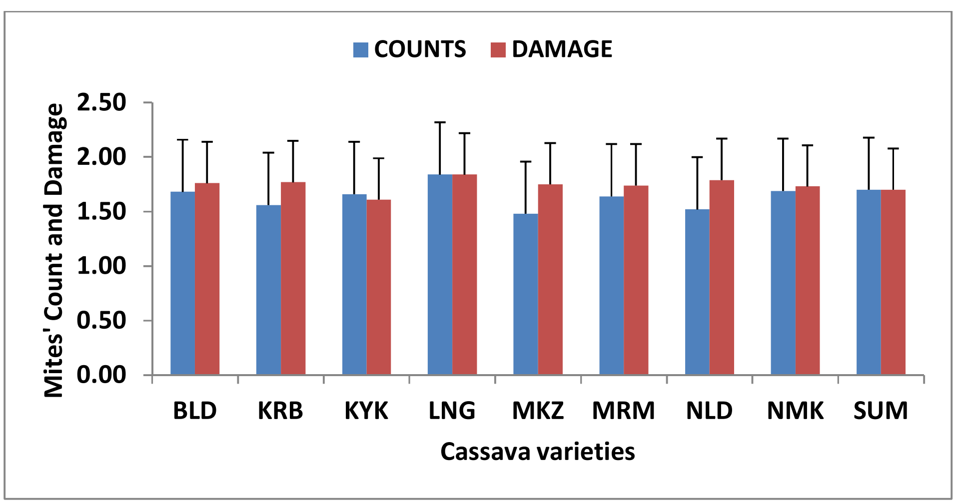

Fig. 3. Performance of some cassava varieties as influenced by *M. tanajoa* damage and counts in Lake Zone, Tanzania

SE±: COUNT= 0.48; DAMAGE= 0.38

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 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 to 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 [24]. *M. tanajoa* severely make damage to cassava up to an estimate of 80% throughout the African continent [25]; [15]. Similarly, the potential for yield loss or reduction by these pests is greater than the cyclical pests like hornworms which cause sporadic defoliation [24].

Fig. 5 indicated that the cassava yield performance by location on root weight did not statistically differed among all the three locations, but however, Ukiruguru recorded the highest root weight (7342 kgh^{-1}) followed by N'gombe (5298 kg^{-1}) with Kwimba (3,833kg^{-1}) having the lowest. However, root number per stand significantly *(P = .05)* differed among the locations where Ukiruguru (4.44) recorded higher root number followed by Kwimba (4.06) while N'gombe (3.51) appeared to be the lowest. Based on the locations, 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.

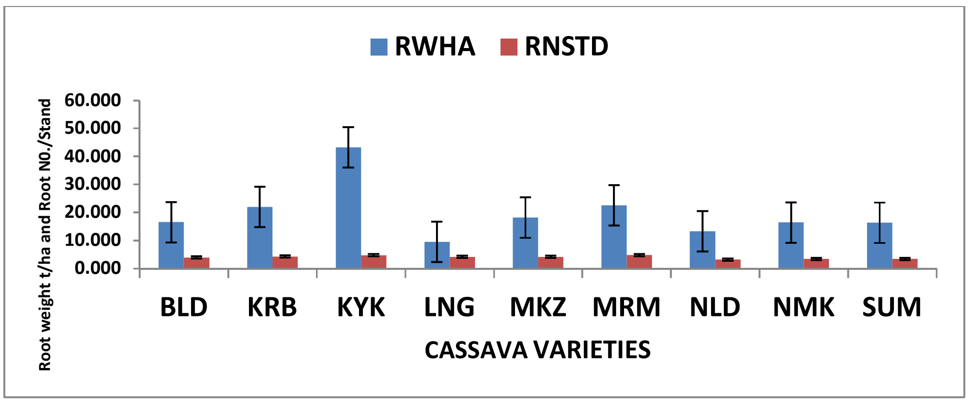

Fig. 4. The root weight (Yield) and root number of some cassava varieties in the Lake zone Tanzania

SE± COUNT= 8.051; DAMAGE= 1.759

***Key:** BLD = Belinde, KRB = Kiroba, KYK = Kyaka, LNG = Liongo Kwimba, MKZ = Mkombozi, MRM = Meremeta, NLD = Naliendele, NMK = Namikonga, SUM = Suma, RWHA = Root Wieght/ha, RNSTD = Root Number/Stand*

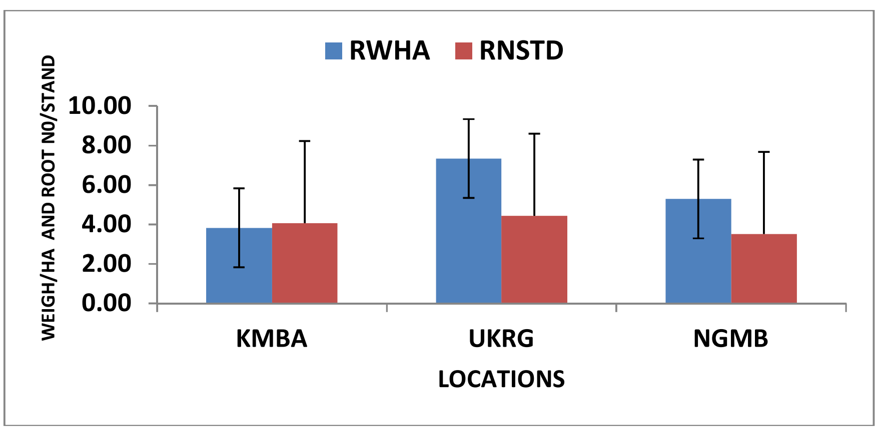

Fig. 5. Cassava root weight (ha^{-1}) and root number per stand as influenced by the three locations in the lake Zone, Tanzania

***Key:** RWHA = Root Weight/ha, RNSTD = Root Number/Stand; **SE± :** RWHA = 4.1610; RNSTD = 0.2312*

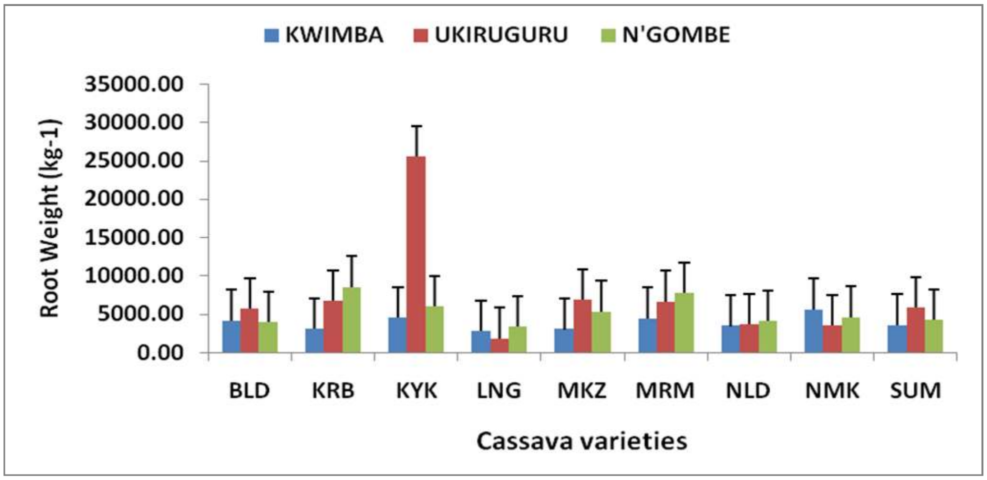

Fig. 6. Interaction effects between variety and location on Average Root Weight (ha^{-1}) as influenced by *M. tanajoa* in the Lake zone, Tanzania

SE± = 7.2071

The interaction effect between variety and location on root weight ha^{-1} was not significant, but Kyaka produced heaviest root weight at Ukiruguru compared to all other cassava varieties in the other locations (Fig. 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 lowest r oot weight was recorded by Liongo Kwimba in all the three locations in the order Ukiruguru, N'gombe and Kwimba respectively. This indicated that although Liongo Kwimba is the most common variety grown in the study areas, it is highly susceptible to *M. tanajoa*.

4. CONCLUSION

The study had indicated that cassava varietal resistance has a significant effect on the population dynamics and damage of *M. tanajoa* in the Lake Zone, Tanzania. The mites' population and damage 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 (7342 kgh^{-1}) followed by N'gombe (5298 kg^{-1}). More so, Kyaka recorded the highest root weight and root number among all the nine varieties with Liongo Kwimba appeared to be the lowest. Farmers should be made aware of the resistance/tolerance of Kyaka while Liongo Kwimba should be improved as it is the most 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.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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