Influence of Abiotic Factors on the Population of *Serangium Parcesetosum*; A Predator of Cassava Whitefly in Uganda

Wamani S.[*]
Uganda Martyrs` University Nkozi, P.O Box 5498, Kampala, Uganda, National Crops Resources Research Institute, P.O Box 7084, Kampala, Uganda

Acipa A.
Ngetta Zonal Agricultural Research and Development Institute, P.O Box 52, Lira, Uganda

Opio M. S.
National Crops Resources Research Institute, P.O Box 7084, Kampala, Uganda

Ocitti P.
National Crops Resources Research Institute, P.O Box 7084, Kampala, Uganda

Wanyana B.
Uganda Martyrs` University Nkozi, P.O Box 5498, Kampala, Uganda

Byalebeka J.
Uganda Martyrs` University Nkozi, P.O Box 5498, Kampala, Uganda

Abstract

Whitefly is a known pest of economic importance in the cassava production systems of Africa. This pest has been reported to cause losses to cassava through direct feeding damage as well as vectoring cassava mosaic disease (CMD) and cassava brown streak disease (CBSD). *Serangium parcesetosum* is a known predator of whitefly (*Bemisia tabaci*) and previous screenhouse and laboratory studies reported that temperature affected the reproduction and survival of this predator. However, these findings lacked precision since they did not depict the field situation. In that regard, it was imperative to initiate a study to help understand the influence of abiotic factors especially temperature and rainfall on the population of S. *parcesetosum* in the cassava growing fields of Uganda. The study was conducted in two agro-ecological zones of Uganda, namely; North Western Savannah Grassland (Lira) and the Kyoga Plains (Kamuli) in the first rains of 2017. Results revealed that temperature caused an increment of 3.5%, 9.1% (Kamuli) and 1.1%, 1.8% (Lira) for mean adult and larvae S. *parcesesotum* per plant respectively. On the contrary, rainfall caused a decrease in the population of S. *parcesesotum* in Lira. Generally, the effect of both temperature and rainfall on the predator population in the field was minimal.
Keywords: Pest; Predator; Vector; Abiotic factors.

1. Introduction

The whitefly (*Bemisia tabaci*) is a pest of economic importance in the cassava production systems of Africa [1]. This pest has been reported to cause losses to cassava, a staple food crop for most of the small holder farmers in Africa [2]. Whitefly causes direct feeding damage to cassava through production of a sugar–rich substrate that supports the growth of sooty moulds which reduce both respiration and photosynthesis of the plant [3]. Also, this pest is a major vector of *Cassava mosaic Geminiviruses* (CMGs) and *Cassava brown streak viruses* (CBSVs) which cause Cassava mosaic disease (CMD) and Cassava brown steak disease (CBSD) respectively. These two diseases in combination, cause significant yield loss in cassava [4]. In Uganda, limited efforts have been directed towards understanding the whitefly as a pest of cassava. In addition, the use of chemicals to control this pest is costly and might have adverse effects on the environment. Therefore, there is a need to explore the use of natural enemies particularly predators in an integrated approach to manage this devastating pest. *Serangium parcesetosum* is a known predator of whitefly (*Bemisia tabaci*) and it has been reported to be evenly distributed and naturally occurring among cassava fields in central Uganda [5]. Furthermore, laboratory and screenhouse studies revealed that S. *parcesetosum* reproduction and survival was highly influenced by temperature, relative humidity and food availability [6]. This author further confirmed that mortality occurred on all developmental stages of S. *parcesetosum* when it was served with a known species of whitefly called *T. vaporariorum*. Much as these screen house and laboratory studies were relevant, they did not depict natural field situations where the predator, S. *parcesetosum* interacts directly with the prey (*Bemisia tabaci*). Therefore, the aim of this study was to understand the influence of abiotic factors especially temperature and rainfall on the population of S. *parcesetosum* in the cassava fields in Uganda.

*Corresponding Author

2. Materials and Methods

2.1. Experimental Sites

Two field trials were established in the first rains of 2017; one on-farm trial in Mbulamuti subcounty, Kamuli district and the other at Ngetta Zonal Agricultural Research and Development Institute in Lira district. These sites (Lira and Kamuli) represent two important cassava growing agro-ecological zones of Uganda, namely Kyoga Plains and North Western Savannah Grassland respectively. These two agro-ecological zones were selected for the study based on their distinct ecological features or conditions and their known history of cassava production in Uganda.

Kyoga Plains agro-ecological zone is characterized by sandy clay alluvial soils with moist semi-deciduous forest, savannas and swamps. The area has a bimodal rainfall ranging from 1215mm to 1328mm (first rains are from March to May while the second begins from October to December). Temperatures range from 15^0C to 32.5^0C. Climate is warm and wet with relatively high humidity and average altitude of 1134m above sea level.

Northwestern Savannah Grassland is comprised of ferruginous sandy loam soils with intermediate savanna grassland and scattered trees. The average annual rainfall ranges between 1340 mm and 1371mm with bimodal rains followed by a dry spell for about 5 months. Temperature and altitude range from $15\text{-}25^o$C and 951-1341m above sea level respectively [7].

2.2. Source and Description of Cassava Varieties

Three varieties namely; Njule Red, Narocass1, and Nase 14, were used for the study. These varieties were selected based on their distinct leaf morphological characteristics.

Njule Red is a landrace, sweet in taste and predominantly grown in the central and western areas of Uganda. It has got long slender smooth leaves.

Narocass1 is a recently released improved variety that is being promoted for its high yields and disease tolerance. It possesses broad smooth leaves.

Nase 14 is an improved variety previously promoted for its high yield, drought and disease tolerance. It has broad hairy leaves.

The planting materials for the respective varieties were sourced from low cassava mosaic and cassava brown streak disease pressure areas (Nwoya and Kabarole districts) and were then visually assessed for the absence or presence of the two diseases. Only clean disease-free fields were used as source of materials.

2.3. Experimental Design and Management

The field experiments were laid out in a Randomized Complete Block Design (RCBD) with three replications and each plot measured 9m x 4m. The plots were separated by 2m from each other while the replicates were separated by 3m. Each stake of 25cm in length with 3-5 nodes was planted at a spacing of 1m x 1m between plants and rows. Weeding was done using a hand hoe so as to avoid competition for resources.

2.4. Field Data Collection

Monthly data collection commenced from 3 to 8 (MAP) months after planting. Data was collected on *Serangium parcesetosum abundance* and *Whitefly Nymph population*.

2.4.1. Data Collection Procedure

2.4.1.1. Serangium Parcesetosum Abundance

10 plants were randomly selected from each of the trial plots. Each plant was then observed from top to bottom (including both the top and underside of all leaves), petioles and the stem. A count of all *Serangium parcesetosum* larvae and adults per plant were recorded [8].

2.4.1.2. Temperature and Rainfall

Data on the average monthly maximum temperature (^{o}C) and total monthly rainfall (mm) was obtained from the metrological stations in Ngetta (Lira) and Kiige (Kamuli) for the period that the experiment was carried out.

2.5. Data Analysis

The data sets for *Serangium parcesetosum* populations, monthly maximum temperature and total monthly rainfall were summarized and mean values obtained. Regression analysis tests were carried out to ascertain the relationship between the mean *Serangium parcesetosum* adults and larvae population and the maximum temperature as well as total rainfall in the field using XLSTAT 2016 statistical package.

## 3. Results and Discussions

3.1. Influence of Temperature on the Abundance of *Serangium Parcesetosum*

In Lira, the mean adult *Serangium parcesetosum* population was first observed at 3 MAP registering 0.2 individuals /plant at the highest average maximum temperature of 30.2 ^{0}c. This then steadily increased up to the peak with 0.9 individuals per plant at a temperature of 29.3^{0}c (6 MAP) before declining up to 0.3 adults at 8 MAP with a temperature of 29.9^{0}c (Figure 1). A similar trend was observed with the mean *Serangium parcesetosum* larvae population in the same location (Figure 2).

Figure-1. Changes in the maximum monthly average temperature with the *Serangium parcesetosum* adults population in Lira
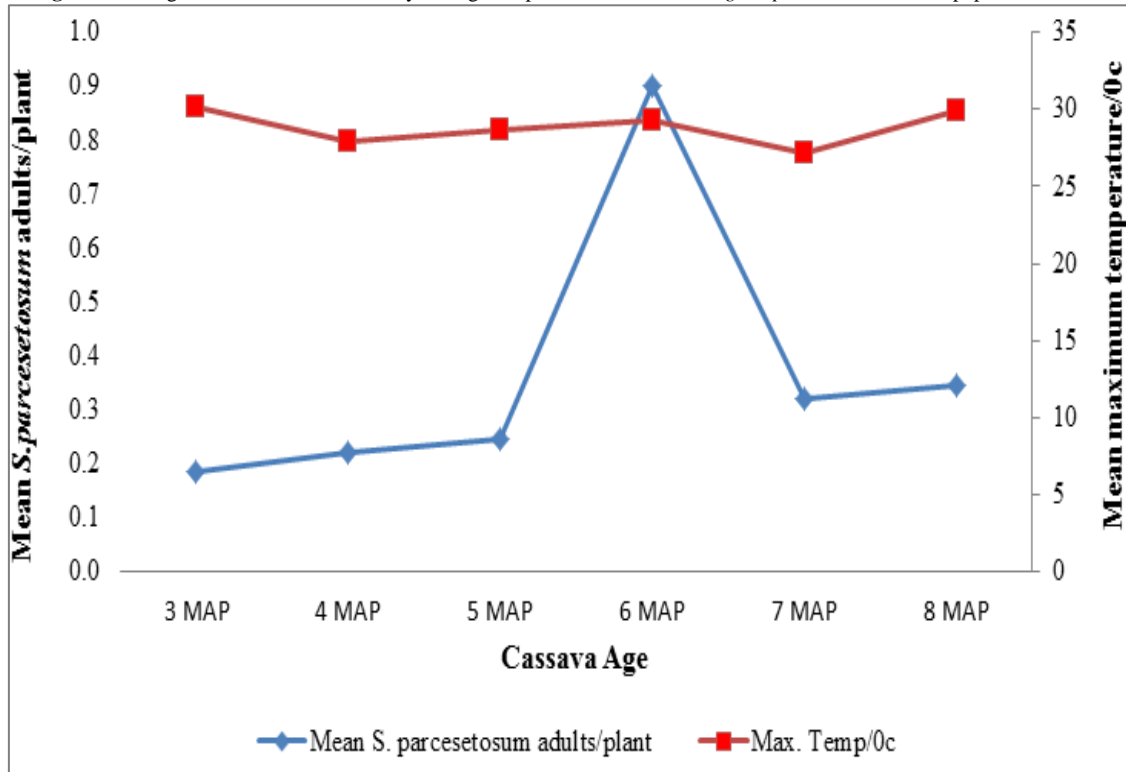
Figure-2. Changes of maximum monthly average temperature with the *Serangium parcesetosum* larvae population in Lira
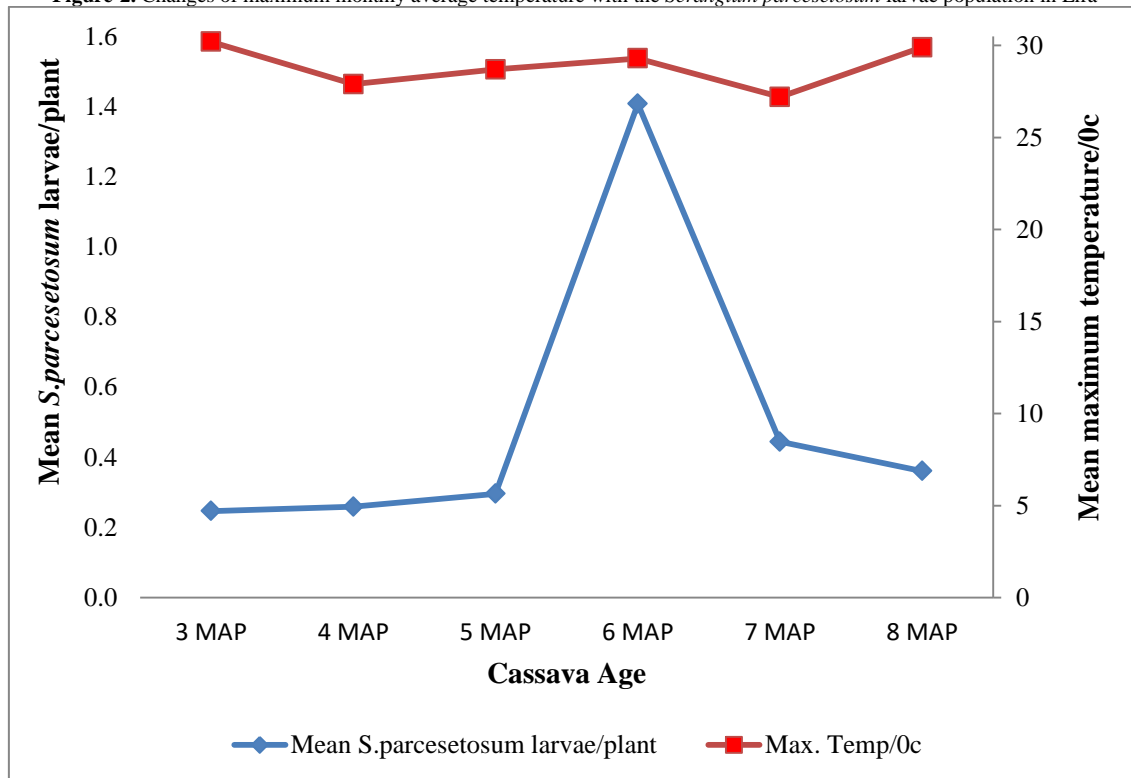
A linear regression test was carried out between both the mean *Serangium parcesetosum* larvae and adults per plant and the average maximum monthly temperature in Lira. 1.1 % (p< 0.845) and 1.8 % (p<0.801) increment in the mean adult and larvae *Serangium parcesetosum* population per plant respectively was registered (Table 1). This was attributed to the mean maximum monthly temperature recorded in the field.

In Kamuli, the mean adult *Serangium parcesetosum* population was first registered at 3 MAP with 0.8 individuals /plant at a low average maximum temperature of 24.0 ^{0}c. This drastically increased up to the peak (6 MAP) with 8.7 individuals per plant at a temperature of 25.0^{0}c before declining up to 4.1 adults at a temperature of 29.5^{0}c (7 MAP). The population thereafter increased to 7.6 adults per plant at 28.5^{0}c (8 MAP) (Figure 3). Generally, a similar trend was observed with the mean *Serangium parcesetosum* larvae population but, a slight variation was observed in the peaking. The mean *Serangium parcesetosum* larvae population peaked at 5 MAP with 22.5 mean larvae per plant at a temperature of 24.2^{0}c (Figure 4).

Figure-3. Changes in the maximum monthly average temperature with the *Serangium parcesetosum* adult population in Kamuli
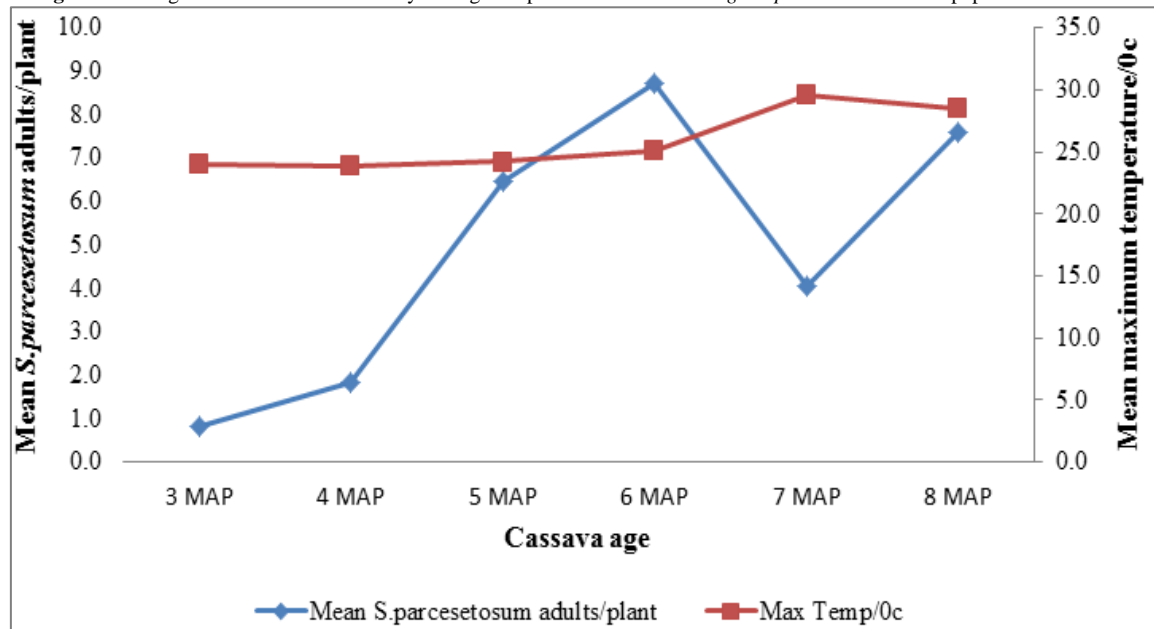
Figure-4. Changes in the maximum monthly average temperature with the *Serangium parcesetosum* larvae population in Kamuli
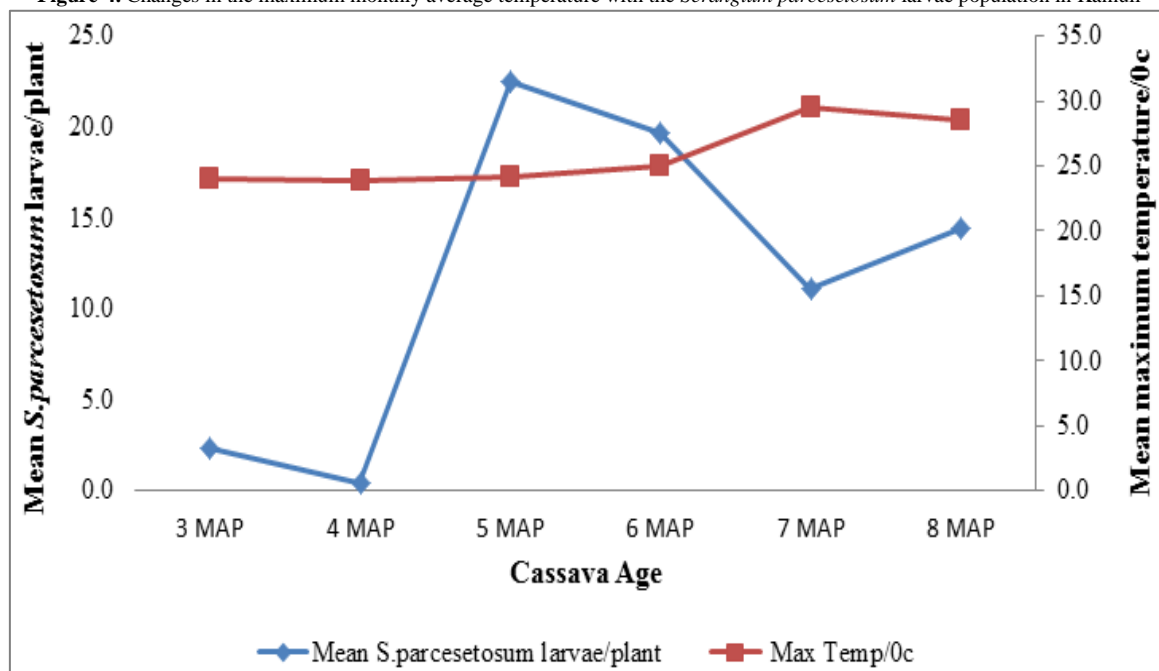
Also, after carrying out a linear regression test between both the mean *Serangium parcesetosum* larvae and adults per plant and the average maximum monthly temperature in Kamuli, 3.5% (p< 0.724) and 9.1% (p< 0.561) increment in the mean adult and larvae *Serangium parcesetosum* population per plant respectively was associated with the mean maximum monthly temperature recorded in the field (Table 1).

Table-1. Regression (R^2) of mean *S. parcesetosum* by mean monthly maximum temperature in the two locations

Adult *S. parcesetosum*	Larvae *S. parcesetosum*
Lira	
0.011 (P<0.845)	0.018 (P<0.081)
Kamuli	
0.035 (P<0.724)	0.091 (P<0.561)

The results suggest that maximum temperature had a minimal effect on the larvae and adult *Serangium parcesetosum* population in the two locations. This literally means that the predator population increased with an increment in maximum temperature. Higher temperature increases the development period of both the whitefly and its predator, *Serangium parcesetosum* and thus increases their population in a very short period of time. This school of thought is supported by research done by Dengel [9] and Legg [10]. However, the small increment in the predator population as a result of temperature observed in the study could have been influenced by many other factors interacting in the field and thus reduced its impact.

3.2. Influence of Rainfall on the Abundance of *Serangium Parcesetosum*

Kamuli registered a low mean adult *Serangium parcesetosum* population at the start (0.8 individuals /plant) at 3 MAP with a low total monthly rainfall of 52.4mm. It then gently increased up to the peak (6 MAP) with 8.7 individuals per plant at moderate rainfall of 138mm. The adult population then declined up to 4.1 adults with highest rainfall of 361.7 mm (7 MAP) and thereafter increased to 7.6 adults per plant with 81.3mm of rainfall (8 MAP) (Figure 5). Still, a similar trend was generally observed among the mean *Serangium parcesetosum* larvae population though a slight variation was observed in the peaking. The mean *Serangium parcesetosum* larvae population peaked at 5 MAP (22.5 mean larvae per plant) with the lowest total monthly rainfall of 46.4 mm (Figure 6).

Figure-5. Changes in the total monthly rainfall with the *Serangium parcesetosum* adults population over time in Kamuli
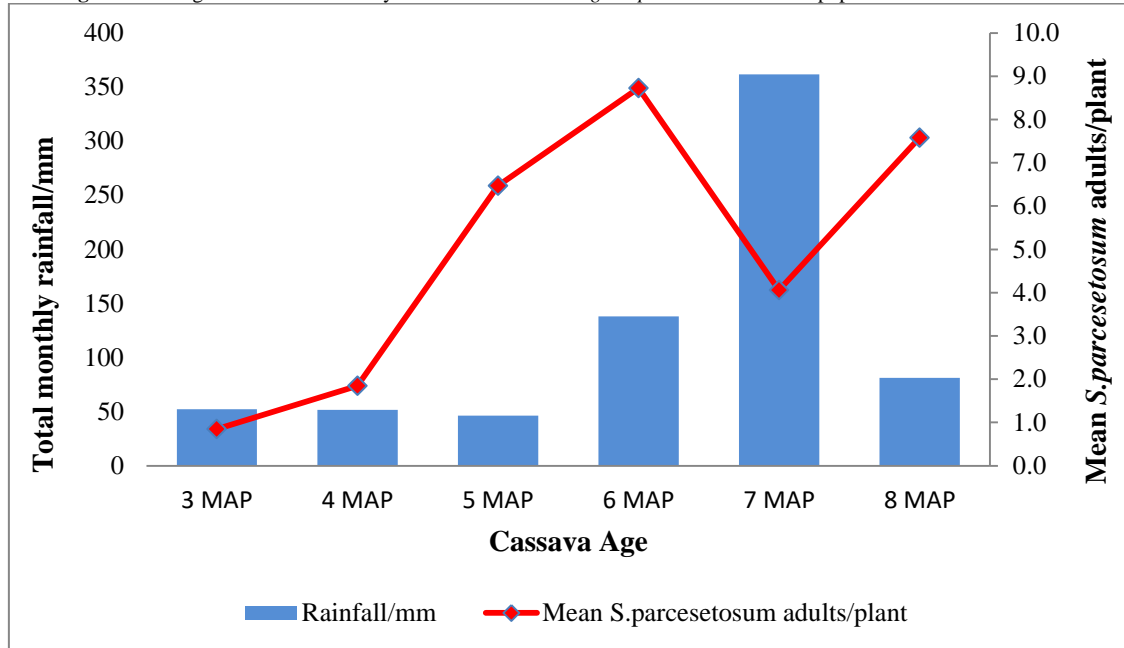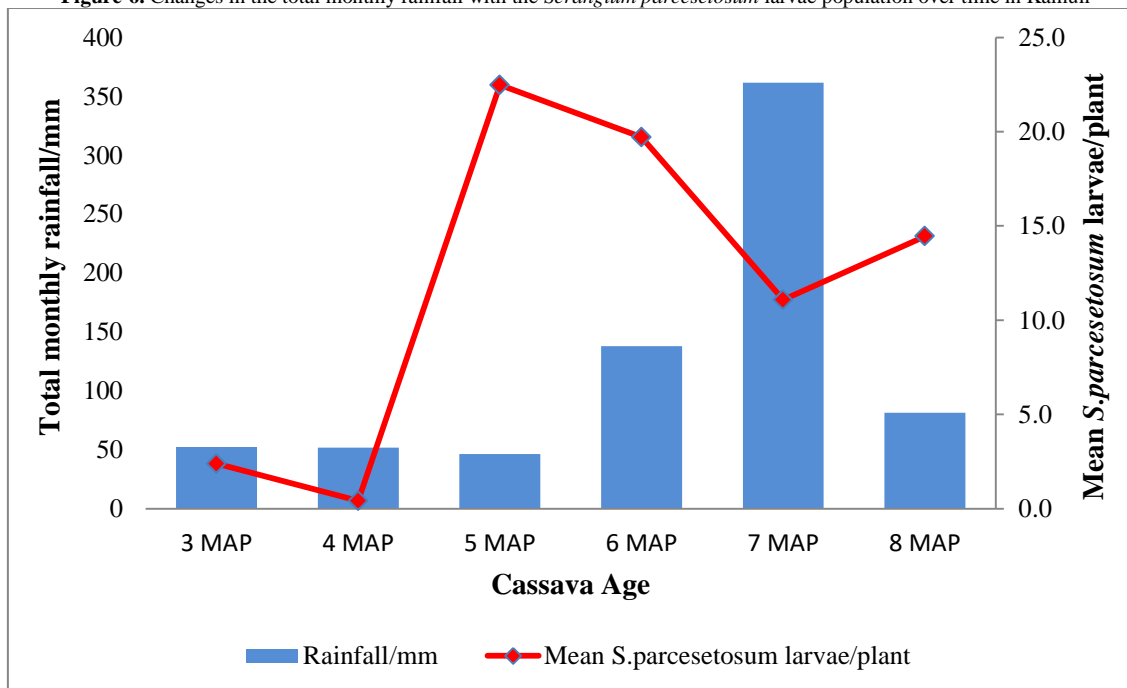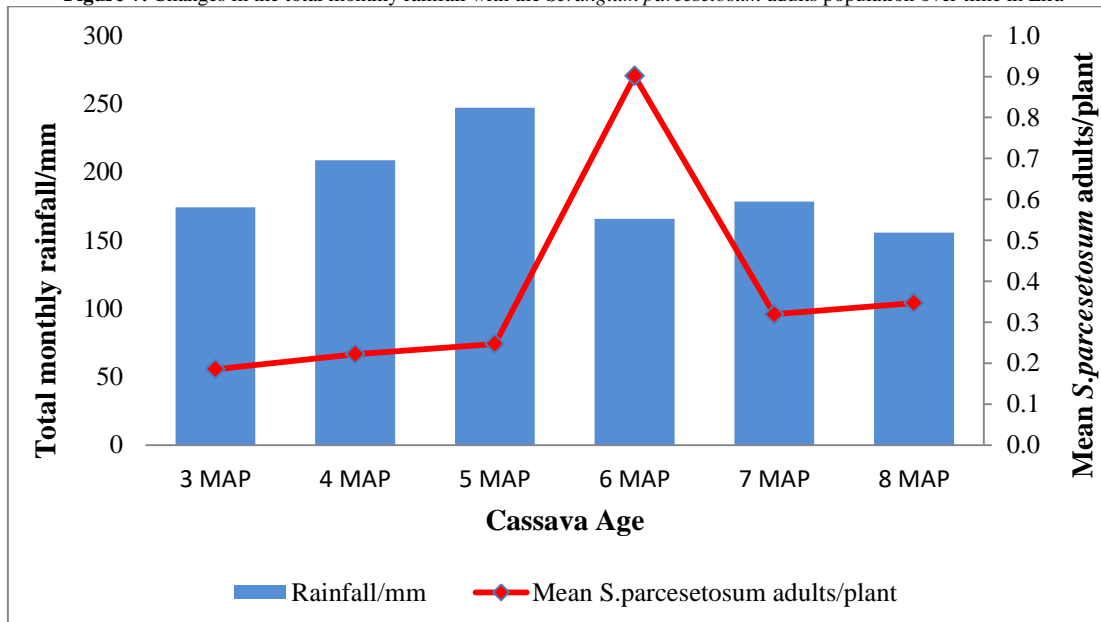

Figure-6. Changes in the total monthly rainfall with the *Serangium parcesetosum* larvae population over time in Kamuli

In order to understand the relationship between the total monthly rainfall and mean *Serangium parcesetosum* larvae and adults per plant, a linear regression was carried out. 0.8% (p< 0.865) and 0.4% (p< 0.901) increment in the mean larvae and adult *Serangium parcesetosum* population per plant respectively was associated with the total monthly rainfall recorded in the field (Table 2).

In Lira, the mean adult *Serangium parcesetosum* population began with a low population of 0.2 individuals /plant with the highest total monthly rainfall of 174.3mm (3 MAP). This steadily increased up to the peak (6 MAP) with 0.9 individuals per plant at 165.7mm of rainfall before declining up to 0.3 adults with 155.7mm of rainfall (8 MAP) (Figure 7). A similar trend was observed with the mean *Serangium parcesetosum* larvae population in the same location (Figure 8).

Figure-7. Changes in the total monthly rainfall with the *Serangium parcesetosum* adults population over time in Lira

Figure-8. Changes in the total monthly rainfall with the *Serangium parcesetosum* larvae population over time in Lira
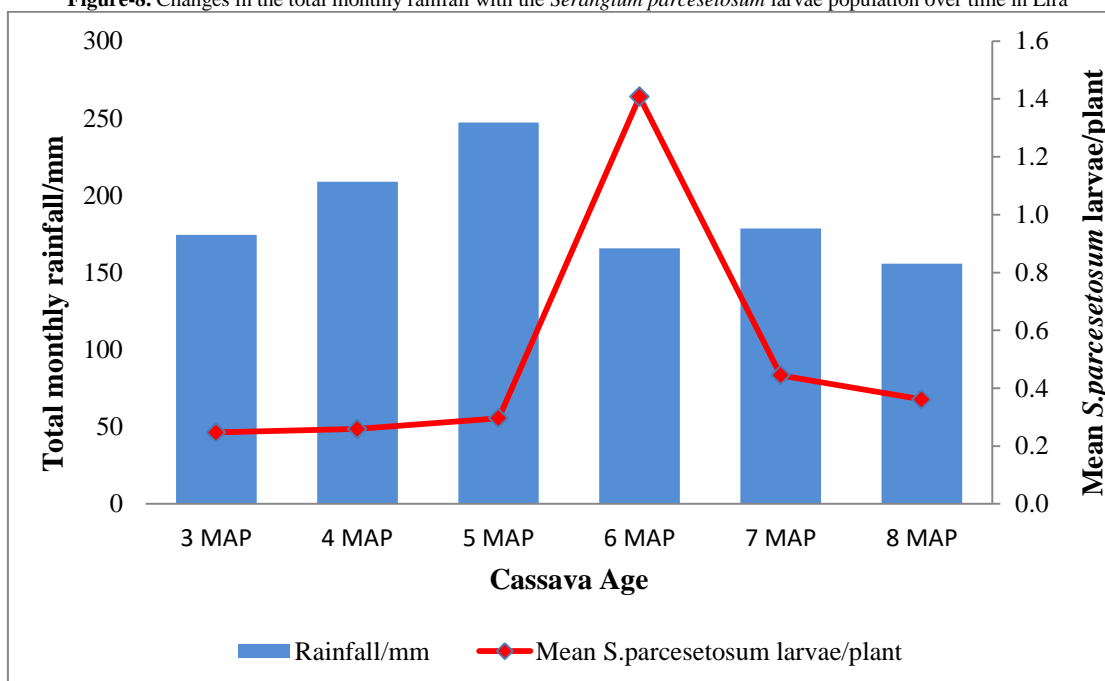
A linear regression test was carried out between both the mean *Serangium parcesetosum* larvae and adults per plant and the total monthly rainfall received in Lira. 14.3 % (p< 0.460) and 16.6 % (p<0.422) decrease in the mean adult and larvae *Serangium parcesetosum* population per plant respectively was registered (Table 2). This was also attributed to the total monthly rainfall recorded in the field.

Table-2. Regression (R^2) of mean *S. parcesetosum* by mean total monthly rainfall in the two locations

Adult *S. parcesetosum*	Larvae *S. parcesetosum*
Lira	
0.143 (P<0.460)	0.166 (P<0.422)
Kamuli	
0.004 (P<0.901)	0.008 (P<0.865)

These observations also indicated that rainfall had a minimal effect on the larvae and adult *Serangium parcesetosum* population in the two locations. This actually means that the predator population increased with an increment in total monthly rainfall in Kamuli while a reverse trend was registered in Lira. According to Fishpool, *et al.* [11] and Legg [10], the observed reduction in the whitefly predator *Serangium parcesetosum* population in Lira could be associated with the mechanical action of heavy rainfall shower that destroyed the whitefly adults and thus reduced the eventual oviposition as well as translating into insufficient amounts of food for the predator.

Dengel [9], on the other hand, registered a high whitefly population during the rainy season and attributed it to the occurrence of the new leaf flushes that attracted the whiteflies because of their palatability for feeding. This could explain the trend of increment *Serangium parcesetosum* population in Kamuli since their prey was in abundance. The minor increment and decrease in the predator population in the two locations as a result of rainfall, could have been influenced by many other factors interacting in the field and thus reduced its impact.

4. Conclusion

The research study established that maximum monthly temperature (^{0}c) had an increasing effect on *Serangium parcesesotum* population. To the contrary, the total monthly rainfall (mm) had a decreasing and increasing effect on the predator population in Northwestern savannah grassland (Lira) and Kyoga plains (Kamuli) respectively. However, the influence of both factors was negligible.

Acknowledgement

References

[1]   Liu, S. S., Colvin, J., and De Barro, P. J., 2012. "Species concepts as applied to the whitefly Bemisia tabaci systematics: how many species are there?" *Journal of Integrative Agriculture,* vol. 11, pp. 176-186.

[2]   Otim-Nape, G. W., Bua, A., Thresh, J. M., Baguma, Y., Ogwal, S., Ssemakula, G. N., and Byabakama, B., 2000. *The current pandemic of cassava mosaic virus disease in East Africa and its control*. Chatham UK Natural resources Institute Catalogue.

[3]   Nelson, S., 2008. *Sooty mold. Plant disease pd 52. College of tropical agriculture and human resources*. University of Hawaii.

[4]   Holt, J. and Colvin, J., 2001. *Whitefly-borne virus disease epidemics. Biotic interactions in plant-pathogen associations*, p. 331.

[5]   Otim, M. H., 2006. *Distribution of natural enemies, biology and behaviour of the major parasitoids of Bemisia tabaci on cassava*. Unpublished Ph.D. thesis, p. 80.

[6]   Al-Zyoud, F., Tort, N., and Sengonca, C., 2005. "Influence of leaf portion and plant species on the egg-laying behaviour of the predatory ladybird serangium parcesetosum sicard (col., coccinellidae) in the presence of a natural enemy." *Journal of Pest Science,* vol. 78, pp. 167-174.

[7]   Food and Agriculture Organization (FAO) Statistics, 2017. "The agro ecological zones of Uganda,." Available: http://www.fao.org/ag/agp/agpc/doc/counprof/uganda/uganda.htm

[8]   Assimwe, P., Ecaat, J. S., Guershon, M., Kyamanywa, S., Gerling, D., and Legg, J. P., 2007. "Evaluation of serangium n. Sp. (col., coccinellidae), a predator of bemisia tabaci (hom., aleyrodidae) on cassava." *Journal of Applied Entomology,* vol. 131, pp. 76–80.

[9]   Dengel, H. J., 1981. "Investigations on the incidence of Bemisia tabaci (Genn.) adults on different cassava varieties." *Plant Research and Development,* vol. 1, pp. 37-49.

[10]   Legg, J. P., 1994. "Bemisia tabaci: The whitefly vector of cassava mosaic Gemini viruses in Africa: An ecological perspective." *African Crop Science Journal,* vol. 2, pp. 437-448.

[11]   Fishpool, L. D. C., Fauquet, C., Fargette, D., Thouvenel, J. C., Burban, C., and Colvin, J., 1995. "The phenology of bemisia tabaci populations (homoptera: Aleyrodidae) on cassava in southern ivory coast." *Bulletin of Entomological Research,* vol. 85, pp. 197-207.