Analysis of some biodiversity of citrus pests and selected annual crops of Meyomessala locality south region Cameroon

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Abstract- Crop damage in agriculture is caused by several threats, including pests or bio-aggressors, organisms that have been destroying cultivated or stored crops for about 10,000 years. This paper looked at the biodiversity of these organisms in a citrus orchard and a field of annual crops (maize, tomatoes and cassava) in the locality of Meyomessala (region of south Cameroon). After sampling in three batches of 100 m^2 each of the two 2000m^2 fields, captures, counts, and valuation of the severity of pest attacks on the aerial parts of the crops were carried out. Ecological indices were estimated using the Shannon Weaver method; as well as Pielou's equitability. Species that could not be captured were carefully photographed on the crop. The results revealed that Zonocerus variegatus was the most abundant pest (800 individuals) and the most formidable on citrus and Locusta migratoria sp; Spodoptera frugiperda, bugs and small snails were the most damaging on annual crops. The Shannon index is 0.55 in the orchard, and 2.68 in the annual crop field. This reflects a higher pest diversity in the annual crops (09 species) than in the orchard (03 species). The equitabilities of the two fields show that there is no dominant species, nor is there an even distribution of individuals in the pest species. The severity of damage is high (about 60% for maize), low (30% for tomato) and cassava (10%); and average (50%) at harvest for the orchard on the 300 m2. The damage is concentrated in the post-flowering and flowering phases.

Index Terms- Pests, biodiversity, Zonocerus variegatus, Locusta migratoria,Spodoptera frugiperda

I. INTRODUCTION

The world's population is increasing over the years. In 2050 it is estimated to be 9.3 billion. This figure for Africa shows that the population will triple from one billion in 2011 (15% of the world's population) to 3.6 billion in 2100, which will be more than double that of Asia, which accounted for 60% of the population in 2011 [3]. This situation generates numerous problems, the most important of which are: the quality of food, water, energy and housing. In all countries of the world, these problems are raised and constitute an important issue for the States which formulated them in 2015 in the form of the new sustainable development program for the 2030 horizon. This program is made up of 17 sustainable development goals for the prosperity of humanity [14]. Indeed, pests are harmful organisms that cause damage to crops through parasitism. In the locality of Meyomessala, a rural town in Cameroon, damage was observed in 2019 on field crops, including: destruction of maize stalks; rotting of maize cobs and tomato fruits; rusty discoloration of cassava leaves and citrus fruits in the nursery. These observations led to the suspicion that pests were present in these fields. This led to the initiation of this study. The aim was to identify the biodiversity of crop pests in the orchard and the annual crop field of the Agricultural Research Institute for Development at its research station in Meyomessala. In order to achieve this main objective, the following was done:

- Identify and make an inventory of the pest species in the fields studied;
- To study the biodiversity characteristics of these pests by calculating the Shannon index and Pielou equitability;
- To evaluate the severity of the damage and to identify the developmental phases in which they occur.

II-MATERIALS AND METHODS

1.1. Study Area

The work is taking place in the locality of Meyomessala, in a citrus orchard of 2000 m2 set up in 2014 by IRAD within the framework of the C2D Par horticulture project financed by the French cooperation, and a plot of peasant annual crops of 2000m^2. The crops grown on these plots are maize, cassava and tomato on the one hand, and fruit trees (lemon (citrus lemon sp); grapefruit (citrus maxima sp) and mandarin (citrus reticulata sp)

on the other. The orchard field is on an area of 2 hectares; the crops are aligned with an interval of semi 2.5 meters and an inter-row spacing of 2 meters; they are sown in rotation (each variety in its own zone in the field). The field of annual crops; maize is also sown in rows with three seeds per stake 0.5m apart.As treatment; there were two manual weedings before flowering; fertilization with fertilizer 20.10.10 and elimination of nematodes in the soil when the crops were installed. After each weeding, a ridging of the stunted plants in particular is applied. The cassava area is only weeded and ridged during its growth. Two cuttings are planted per planting for cassava. For tomato; this crop was already at the two-month stage of growth when the trial started. We therefore went straight to collecting data on pest species and observing damage; treatments and technical itineraries were not monitored.

The agro-ecological zone of the Meyomessala locality is a forest zone with bimodal rainfall. The climate of the Meyomessala commune is hot and humid, of the classic Guinean equatorial type. It is characterized by four distinct seasons: A short rainy season from mid-March to the end of June; a short dry season from the end of June to mid-August; the long rainy season from mid-August to mid-November; the long dry season from mid-November to mid-March. Temperatures are relatively warm with an annual average of around 24.7°C[13].. These temperatures sometimes reach 30°C during the months of january and april and 19°C between september and december. The average annual rainfall is around 1800mm. Ferralitic soils: made up of acidic or highly denatured rocks, they have good physical properties; they are deep soils with good permeability and a stable microstructure that makes them less susceptible to erosion than other types of soil; they are well drained, but can become dry (edaphic drought) due to their low water retention capacity by the mineral fraction of the soil.

1.2. Plot selection criteria

The plots are selected basis on the presence of pests in the fields, the presence of damage (gnawed plant, destroyed plant, spots on the leaves, fruits, wilted leaves, etc.) and on the fact that the crops installed are mainly cultivated by the local farmers; they are also the most traded in the markets and consumed in the locality. The orchard plot consists of three perennial crops of citrus fruits; installed on 2000m^2 it was set up within the framework of the C2D horticulture project at the IRAD agricultural research station of Meyomessala. The annual crop field is a set of three separate sub-units of fields in this research Centre. Cassava occupies 1000 m^2 and is close to the maize sub-unit 500m2 and tomato 500m^2. The latter crop is planted in a swamp. Data collection for the annual crop field takes place in the rainy season of the first crop year of 2020; while that of the orchard takes place in the month of january to march during the main dry season of the same year.

1.3. Method

Field trips to make observations took place over three months. These observations were made during the post-emergence phase (after 3 weeks of semi-irrigation), and the pre-flowering phase for maize; tomato and cassava. For the orchard, this observation took place during the fruiting phase. Indeed, Metral showed that; maize and potatoes are most attacked at the 4-leaf stage and at harvest, the pests responsible for leaf nibbling; slugs have a nocturnal activity and their displacement is 2 to 5m [9]. In two fields of 2000 m^2, three samples of 100 m2 are taken in the orchard and two samples in field 2. This study takes place in November 2019 in the dry season for the orchard (field 1), and in the field (field 2) where the tomato crop is grown in a swamp. It starts at the same time and ends in February 2020 with interruptions due to the coronavirus pandemic.

The aim was to identify the pest species attacking these crops and to determine the species richness, i.e. the number of species of each pest. The pest stages of the insect group encountered were identified, as well as the severity of the attacks. Macrocosmic observations of all samples (100 m2 x 3 field 1) were made and the severity or percentage of attacks on leaves, stems, flowers and fruits (aerial parts) was estimated according to the scaling method codified below. Following this method, we observe the annual crop plot at the post emergence phase and the pre flowering phase. For the orchard this observation is made at harvest. For each crop we estimate the percentage of organ attacks (leaves, stems, flowers and fruits) after an observation of all the plants on the whole sampled surface. Thus, according to this table, when the estimate of the damage on the leaves, flowers and fruits is 60% or ¾ of the field sample, then the severity is high. And so on.

Figure 1 Estimation of damage on organs

Collor code	Severity	Details
	Low	This represents 2 to 5 leaves, flowers, fruits with light spots or eaten away and the stem not destroyed; on an area of 20% or 1/4 of the field sample
	Medium	All these organs show spots and the stem is not destroyed; on a surface of 50% or 2/4 of the field sample
	High	Leaves, flowers, fruit or stem destroyed over an area of 60% or 3/4
	Extremely high	Fruit destroyed or plants cut down or missing over an area of 70% to 100% or 4/4

The crops studied are not uprooted to study the roots and tubers, nor are they dissected to analyze the tissues. The characterization of the biodiversity of these fields is obtained by calculating ecological indices (Shannon index and equitability). The Shannon index is an index used to measure biodiversity in an ecosystem. This means the number of species in the environment (species richness) and the distribution of individuals within these species or equitability. Also called pielou equitability (or regularity) it is the ratio of the diversity H' to the maximum diversity Hmax. Equitability is therefore obtained by dividing the value of the Shannon diversity index by the logarithm to base 2 of the taxonomic richness [12]. It varies between 0 and 1, tending towards 0 when one specie dominate, and is 1 when all species have same abundance [11]**.** When almost all the equitability index determines either the closeness or the distance between H' and Hmax. These ecological indices were calculated according to the following formulae:

$$H' = -\sum_{i=1}^{s} P_i \log_2 P_i$$

(1)

With,

S = total number of species

$P_i = n_j / N$, relative frequency of species

n_j = Relative frequency of species j in the sampling unit

N = Sum of specific relative frequencies

The higher the value of H' the greater the diversity

The different species are collected by hand. For insect pests; they are collected in alcohol; and the other species including snails are put in plastic bags and labelled. The species are collected from the ground and from plants in the field. The fast-flying insects during collection are stunned, photographed and preserved in 70% alcohol. Fast-flying or long-hopping insects such as migratory locusts that cannot be captured are photographed on the crop and counted. For snails, even dead individuals and fresh empty shells are collected.

The various samples collected are taken to the work site outside the field, where isolation and identification of the species and developmental stage are carried out. This first identification step is based on scientific documents such as: the Guide for school fields of the World Food and Agriculture Organization of 2018[5]; the vade mecum of the locusts of the sahel of Launois-luong of 1989 and the operational acridology collection "the desert locust in the sahel" N05 and N06 of 1990[8]; the illustrated catalogue of the main insect pests and auxiliaries of crops in Guyana of 2014[7], we identify the collected species. For species that are not mentioned in the publications or that are new to us, photos and samples are taken to the entomology laboratory of IRAD in Nkolbisson for identification in their collection. However, the corona virus epidemic did not allow for this, as the people in charge were not in post.

The second step consisted of macroscopic observations of the crops in order to identify the type of attack and their severity according to the estimated scale (low, medium, high, very high). The data collected is reported on the study sheets. Sanitary precautions to avoid infection by the secretions of these organisms are taken, in particular; the wearing of plastic gangs and safety goggles; and the fact that the organisms are not separated from their shells, nor crushed, are they immediately immersed in alcohol.

III-RESULTS

3.1 Pests, Intercropping, Density and Severity

Crops and parts attacked in the orchard and fields

These results reveal that for annual crops, the leaves would be the only aerial parts attacked for cassava and tomato, which does not appear to be the case for maize where the stalk and flowers, fruits also appear to be attacked. This also applies to the citrus varieties Citrus latifolia (lemons) and Citrus reticulata (mandarins) which are attacked on the leaves; while Citrus aurantiifolia (lemons) and Citrus maxima (grapefruits) are attacked on the fruits and leaves.

Table 1: Crops and parts attacked

Citrus fruits	parts attacked	annual crops	parts attacked
Citrus aurantiifolia	Fruits and Leaves	*Zea mays*	Leaves and stems
Citrus latifolia	Leaves	*Manihot esculenta*	Leaves
Citrus maxima	Fruits and leaves	*Solanum lycopersicum*	Leaves
Citrus reticulata	Young leaves		

3.2 Biodiversity of pests in citrus and annual crop fields

The biodiversity of pests encountered in maize, tomato, cassava, and citrus crops Citrus aurantiifolia and Citrus latifolia, Citrus maxima and Citrus reticulata is presented in Tables 2 and 3. Three pest species (Zonocerus variegatus; Tettigonia viridissima; Locusta migratoria) can be observed in the fruit orchard and 9 species in field 2 of annual crops (maize, tomato, cassava).

Table 2: Biodiversity of pests found on citrus

Pests	Scientific name of the species	Order	Familly	Damaged crops
Stink locust	*Zonocerus variegatus*	*Orthoptera*	*Pyrgomorphidae*	
Migratory cricket	*Locusta migratoria*	*Orthoptera*	*Acrididae*	All citrus fruits
Grasshopper	*Tettigonia viridissima*	*Orthoptera*	*Tettigoniidae*	

Table 3: Biodiversity of pests encountered in annual crops

Common name of the pest	Scientific name	Order	Familly	Damaged crops
Stink locust,	*Zonocerus variegatus*	*Orthoptera*	*Pyrgomorphidae*	Maize
Migratory cricket	*Locusta migratoria*	*Orthoptera*	*Acrididae*	
Grasshopper	*Tettigoniidae viridissima*	*Orthoptera*	*Tettigoniidae*	
Blue aphid,	*Myzus persicae*	*Hemiptera*	*Tettigoniidae*	
Stink bugs	*Leptoglossus occidentalis*	*Hemiptera*	*Pyrrhocoridae*	
Small snail	*Hélix aspersa*	*Stylommatophora*	*Helicidae*	
Hedgehog,	*Erinaceus europaeus*	*Erinaceomorphora*	*Erinaceidae*	
Stinkhopper,	*Zonocerus variegatus*	*Orthoptera*	*Pyrgomorphidae*	Cassava
Grasshopper	*Tettigoniidae viridissima*	*Orthoptera*	*Tettigoniidae*	
Blue aphid,	*Myzus persicae*	*Hemiptera*	*Tettigoniidae*	
Ladybird	*Coccinella septempunctata*	*Coleoptera*	*Scyminae*	
Legionnaires' caterpillar	*Spodoptera frugiperda*	*Lepidoptera*	*Noctuidae*	
Migratory locust,	*Zonocerus variegatus*	*Orthoptera*	*Acrididae*	Tomato
Blue aphid,	*Myzus persicae*	*Hemiptera*	*Tettigoniidae*	
Ladybird	*Coccinella septempunctata*	*Coleoptera*	*Scyminae*	
Armyworm	*Spodoptera frugiperda*	*Lepidoptera*	*Noctuidae*	
Whitefly	*Bemisia tabaci*	*Hemiptera*	*Aleyrodidae*	

3.3 Number of pest individuals in each field

The results of species richness (number of species) and individuals per species in the different samples of each field studied are presented in Table 4. Migratory locusts, snails,

aphids, bugs were found to be the most abundant in annual crops (20; 20; 18; 16) respectively in terms of % of species.

Table 4 Distribution of individuals per sample

	FIELD 1 Fruit orchard					
	Sample 1: Mandarin trees	Number of individuals	Sample 2: Lemon trees	Number of individual	Sample 3: grapefruit trees	Number of individuals
Dry season for orchard	*Zonocerus variegatus*	400	*Z.variegatus*	300	*Z.variegatus*	100
	Tettigoniidae viridissima	20	*T.viridissima*	22	*T.viridissima*	10
	Locusta migratoria	10	*L.migratoria*	5	*L.migratoria*	17

	FIELD 2 Annual crops			
	Sample 1: Maize, cassava	Number of individuals	Sample 2: Tomato	Number of individuals
Rainy season for annual crops	*Locusta migratoria*	30	*Locusta migratoria*	33
	Zonocerus variegatus	12	*Tettigoniida viridissima*	12
	Tettigoniidae viridissima	11	*Helix aspersa*	30
	Spodoptera frugiperda	5	*Myzus persicae*	15
	Helix aspersa	33	*Bemisia tabaci*	6
	Myzus persicae	41		
	Coccinella septempunctata	50		
	Erinaceus europaeus	3		
	Leptoglossus occidentalis	50		

3. 4 Ecological indices

The Shannon index is an index used to measure biodiversity in an ecosystem. This is the number of species in the environment (species richness) and the distribution of individuals within these species or equitability. Equitability is therefore obtained by dividing the value of the Shannon diversity index by the logarithm to base 2 of the taxonomic richness[12]. The results in Table 5 show that this index is 0.55 in the orchard and 2.68 in the annual crop field. The equitabilities (the distribution of individuals in a species and species in a specific community) of this index are 0.84 for the N02 field and 0.36 for the annual crop field.

Table 5: Shannon Weaver index of the two fields and their equitabilities

Field 1 Orchard	**Number of individuals ni**	**Specific frequency pi=ni/N**	**Log_2pi**	**- piLog$_2$pi**
Zonocerus variegatus	800	0,90	-0,15	0,13
Tettigoniidae viridissima	52	0,05	-4,33	0,27
Locusta migratoria	32	0,03	-5,06	0,15
	N_1= 884			
Shannon's Indice : H_1'= -£ pi log$_2$ pi	**0.55**			
equitability: $E_1= H_1'/log_2 S1$	**0,36**			
S1=3 ; 0,30				
Field 2 Annual crops	**Number of individuals**	**Specific frequency pi=ni/N**	**Log_2pi**	**- piLog$_2$pi**
Locusta migratoria	63	0,203	-2,30	0,46
Tettigoniidae viridissima	23	0,074	-3,76	0,27
Spodoptera frugiperda	5	0,016	-5,98	0,09
Helix aspersa	63	0,203	-2,30	0,46
Myzus persicae	56	0,181	-2,47	0,44
Coccinella septempunctata	40	0,129	-2,96	0,38
Erinaceus europaeus	3	0,009	-6,81	0,06
Leptoglossus occidentalis	50	0,161	-2,64	0,42
Bemisia tabaci	6	0,019	-5,73	0,10
	N_2=309			
Shannon's Indice: H_2'= -£ pi log$_2$ pi	**2,68**			
equitability: $E_2= H_2'/log_2 S2$	**0,84**			
S2=9				

3.5 Attack distribution and severity by growth phase

The results on the distribution of attacks and their severity presented in Table 6 show that the majority of pest attacks are found on the leaves. The 5-leaf stage of the plant, where the plant size is around 10 cm, before flowering would be the most susceptible (the plant is destroyed). Maize is the most attacked annual crop because the severity of the attacks it suffers is high, i.e. about 60% of the plants have their leaves and fruits gnawed and destroyed. In a sample where the percentage of attacked leaves is more than 50% and the plants are destroyed, the attack is considered high.

Table 6: severity of attacks and distribution in crop development

Growth phase	Crops planted	Attacked parts	Condition of the plant	Severity
Post levée (after 3 weeks)	Maize	60% of the leaves of the field plants 50% of the stems of the plants in the field	Destroyed	High
	Tomato	10% of the leaves in the field	The stem is not destroyed	Low
Before flowering	Maize, Tomato, Cassava,	60% of the leaves of the field plants 30% of the leaves in the field 10% of the leaves in the field	Destroyed for Maize	High for maize, low for others
Harvest	Mandarin, Lemon, Grapefruit	45% of the leaves in the field 10% of field fruits 10% of the fruit in the field	The stem is not destroyed but the lemon trees are more spotted	Medium

3.6. Most damaging pests and crops concerned

Table 7: Most damaging pests

Attack	Severity	Responsible	Cultures	Field
Leaves, flowers, fruits gnawed or spotted on 60% of the field		*Locusta migratoria* *Spodoptera frugiperda* *Leptoglossus occidentalis* *Helix aspersa*	Maize,	Annual Crops
Leaves, fruits gnawed and necrotic on 50% of the field		*Zonocerus variegatus*	All	Orchard

3.7. Developmental stages of the most damaging insects

The pupal stage (Figure 3) is the main stage of locusts found in the field of annual crops, individuals measuring between 1 cm and 2 cm for Locusta migratoria and 1 cm for Zonocerus variegatus. For Spodoptera frugiperda armyworm on maize, larvae are the most common developmental stage encountered.

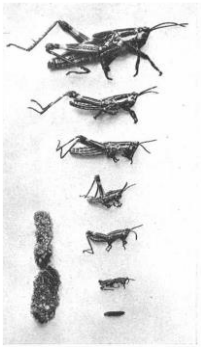

Figure 2. biological cycle of Zonocerus variegatus[2],[10]
Bottom (left): ootheque
Right (from bottom to top): Egg, 1st stage larva, 2nd stage larva, 3rd stage larva, 4th stage larva, 5th stage larva,pseudo-pupal stage (life size)

IV-DISCUSSION

The high abundance of Zonocerus variegatus in the orchard can be explained by the fact that this organism has a close trophic specificity with the leaves of citrus trees because of the odours they give off. In fact, in the grasses near the orchard the number of individuals is almost zero. It is possible that the attractiveness of citrus is greater than the surrounding grasses. Citrus trees are phenotypically related species (they are all members of the Citrus family). In the nursery you cannot distinguish a Citrus reticulata plant from a Citrus maxima and Citrus latifolia, and in the orchard this distinction is contrasted with the absence of fruit and they are roughly the same size. This is why they are planted together. It is therefore assumed that it is an obligate pest, which has a reduced food spectrum. The individuals of Zonocerus variegatus encountered were about 1 cm long, they are nymphs, or larvae unlike the adults.
which are often up to 3 or 5 cm long. They move in groups (gregarious), which explains the strong pest effect they have locally.

In annual crops, the migratory locust, armyworm and stink bugs cause significant damage to maize. For the bugs, this damage is concentrated on the leaves [2], [9] and more precisely on the leaves rolled up in the Centre of the crop for maize.

The Shannon index is close to zero (0.55) in the orchard, which means that the specific diversity of pests is higher in the annual crop field than in the orchard where this index is (2.68). The stinkpot is the dominant species as shown by the abundance (90%) and the equitabilities of the two fields show that there is no dominant species, nor equi-parity (its value is not 1 so not all species have the same abundance). of individuals in the pest species. This low biodiversity of pests in the orchard can be explained by the height (4 m on average) of these fruit trees, their age (6 years), their leaves which are tougher than those of maize, cassava and tomato. And also by the biology of these various pests (migratory locust, armyworm) which do not fly higher, nor climb higher for snails, as they are essentially phytophagous

The armyworm was most commonly found in the maize field in larval form, and is known to play an important role in crop damage according to [5]. The most important damage was observed before flowering and was caused by these two pests. It can be said with certainty that these pests are harmful to annual crops, especially maize and cassava. Indeed, CIRAD in 2007 and FAO in 2018 showed that the migratory locust, 75-80 mm in size, is capable of eating 3g/d and that it is the worst invasion in 15 years on 20% of the land area[15]. They also believe they are destroying all plant life. A swarm of 500 million locusts eats the equivalent of 100 elephants or 2 million people, and swarms, each of which is potentially made up of hundreds of thousands of locusts, are capable of travelling 150 kilometers a day and ravaging rural livelihoods to feed and breed. This role as a formidable pest is also apparent from its presence in the two fields (commons) studied.
In the biodiversity of pests of annual crops and citrus identified, insects are the most abundant pests. This can be explained by their prolificacy (high reproductive capacity), their ability to have several generations a year, and their pterygote locomotor system (winged insects), which allows them to walk, jump and fly, and therefore to colonize large areas. For example the mealy bug produces 150 L1 stage larvae which feed within 6 hours of hatching. It has three generations per year, as is also the case with species such as Spathosternum pygmaeum. This species has embryonic diapause and two generations in the rainy season in the Sahelian and Sudanian zones. On the other hand, in the Guinean zone, it reproduces all year round, without diapause [10] The passage to the adult state lasts 8 to 21 days. For the armyworm, up to 1000 eggs are laid per woman, the life span is 14 to 21 days as a larva, 9 to 13 days as a chrysalis and 12 to 14 days as a butterfly.

Attacks of Zonocerus variegatus on citrus are characterised by discoloration of the leaves, which turn grey, or by local dead leaves. These leaves fall off and die back, causing the plant to stop growing.

Maize is the most attacked annual crop because the severity of the attacks it suffers is high, i.e. about 60% of the plants have their leaves and fruits nibbled and destroyed, while it is low (30% for tomatoes) and cassava (10%). For fruit trees it is the lemon trees, certainly because they are used as rootstocks.

It is therefore very important to control these pests, which not only have a negative impact on research and development in this IRAD station, but also on food security and the economy of agricultural entrepreneurs. They are also often carriers of parasites that can cause diseases to humans, zoonoses, if the food is not well washed or cooked before consumption.

CIRAD, in 2007, mentions in this sense that the diseases suffered by locusts are caused by three groups of pathogens:
- Protozoa: Gregarina, Nosema, amoeba as pathogens,
- Fungi: Fusarium, Aspergillus, Entomophtora, Metarrhyzium,

- Bacteria: Cocco bacillus acridiorum, Pseudomonas, Bacillus thuringiensis [15].

V-CONCLUSION

The aim of this research was to identify the biodiversity of pests of citrus and some crops in the locality of Meyomessala. The results revealed three (03) pests in the orchard field and those in the annual crops field; nine (09). It was also found that the stink locust Zonocerus variegatus is the most abundant (800 individuals) and the most formidable pest of the citrus crops, Citrus reticulata; Citrus maxima and Citrus latifolia respectively mandarin, grapefruit and lemon; and the migratory locust, armyworm, bugs and snails those of maize, tomato, and cassava The calculated Shannon ecological indices are close to zero in the orchard, which means that pest species diversity is higher in the annual crop field (2.68) than in the orchard (0.55). Maize is the most attacked annual crop because the severity of the attacks it suffers is high, i.e. about 60% of the plants have their leaves and fruits nibbled and destroyed. This high population of Zonocerus variegatus causes a serious problem for the orchard crops because the severity of the attacks is medium which can considerably reduce fruit production in this field; this is also the case for the high diversity pest of maize in the case of annual crops which destroys the aerial parts at 60% before flowering although for cassava and tomato this severity is low. All this will require rigorous pest control to reduce this severity in both fields.

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