Insect Abundance and Diversity on Cultivated *Amaranthus Spp.* (Amaranthacea) in Meru County, Kenya*

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Abstract

Purpose: *The focus of this research was to identify pests and natural enemies of amaranth as well as quantify the losses as a result of these pests.*

Materials and Methods: *Surveys of insect pests were done on randomly selected farms of farmers who were growing amaranth in Meru County between April 2012 and April 2013. The insects were collected by hand, sweep nets, knock down and pit-hole techniques depending on the type of insect.*

Results: *A total of 1256 specimens were collected, stored in alcohol, pinned on boards, identified and archived at National Museums of Kenya, Nairobi. Insect pests were classified into 5 orders, 15 families and 33 species with the most damaging insects being Cletus sp., Hepertogramma bipunctalis and Hypolixus nubilosus. The natural enemies were grouped into 2 orders, 5 families and 8 species.*

Conclusion: *There are diverse insect pests attacking amaranth causing considerable damage to yield of both leaves and grain hence requiring control measures. The natural enemies can be conserved and used for biological control. This is the first study on diversity and quantification of the losses caused by insect pest on amaranth in Kenya.*

Key Words: Amaranth, Insect pests, Natural enemies, Economic damage, Yield loss

Introduction

Amaranth has been widely regarded as a stubborn weed or food for the poor in the past years especially in many parts of Africa including Kenya, however, for the past one decade there has been a sharp rise in the demand and consumption of Amaranth (Bosch *et al*., 2009). This can be attributed to increased awareness on the importance as a valuable source of food, medicine and income for small-scale farmers (Maundu *et al*., 1999 and Ouma, 2004). There is a growing need among farmers in Kenya to diversify agricultural production especially vegetable production, in this case, shift from over-reliance on exotic vegetables and grow more African Leafy Vegetables (ALVs) that include both indigenous and traditional vegetables (Mbugua *et al.,* 2005).

The main constrain is that there is limited research that has been put in to enhance production of ALVs (Ouma, 2004). As many other crops Amaranth production faces a major challenge due to pest infestation. Over-reliance on organochlorides and organophosphates or their derivatives as a control strategy for pest is facing resistance due to rising impact on the environment and health of human beings and their animals (Sithanantham, 2004 and Losenge, 2005). This is due to persistence in soils and bioaccumulation. Use of biological control agents, pesticides derived from natural sources, cultural control of pest and judicious use or complete abstinence from persistent pesticides is the way forward in the management of insect pests (Losenge, 2005).

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A good integrated pest management strategy employs correct identification of insect pests and a good understanding of their biology as a key pillar to their control (Anyango, 2006). This involves monitoring the pest population as well as noting the stage of insect development and only mobilizing control measures when the pest numbers reach the economic injury levels (Sithanantham *et al.*, 2004).

Several pest surveys have been conducted in other parts of the world, for example, Mexico and Brazil (Torres *et al.*, 2011 and López *et al.*, 2011). However, information on the occurrence, diversity insects and quantification of losses as a result of pest damage on cultivated amaranth in Kenya is still very limited.

2.0 Materials and Methods

2.1 Study site

The research was conducted in Meru county, Buuri division, Nchoroiboro and Ruiri location. Sampling of the insect pests and their natural enemies was done from eight farms of farmers who were randomly selected from those growing amaranth in the two locations. The demonstration plots were located at Meru University College of Science and technology (MUCST). The identification and preservation of insect specimen was conducted at the National Museums of Kenya – Zoology Department, Invertebrate Zoology section, in Nairobi. The study area lies between 300 – 5199 meters above sea level (summit of Mount Kenya) with rainfall amounting between 380 mm and 1000 mm annually except for the regions closer to the Mountain. Rains come in two seasons with long rains in Mid-March to May and short rains October to December (Ministry of Planning and National Development, 2002).

2.2 Growing of Amaranth

Amaranth was grown according to the regional agricultural practices for this crop, which consist of tilling, harrowing, plowing, transplanting, applying organic fertilizer, first hoeing, second hoeing, harvesting (of leaves or grain), threshing and drying of grains.

2.3 Collecting methods

Slow moving and sedentary arthropods were collected by hand. The plant were searched visually for possible insect pests which were then be collected into vials, labeled and taken to the laboratory at National Museums of Kenya for identification. Healthy plants were also uprooted and stems and roots dissected to examine the presence of phytophagous insects that cause damage inside the stems and roots. Beating sheets were used to collect camouflaged or hidden insect pest where a small sheet was placed beneath the plants and the insect pests knocked down from the plant onto the sheet by beating with a stick. The insects were then picked up from the sheet with aid of a hand lens and forceps and placed into vials. Flying insects e.g. bugs were collected using aerial nets.

2.4 Identification of immature stages of insects

Healthy looking stems were uprooted and dissected to observe if they were infected by tunneling insects. The larvae collected from inside the stems were incubated on soil in a killing jar and covered with a net. Small cuttings of amaranth stem and leaves were added to provide food for the grabs. A little water was added every after two days until the adult emerged. Successful experiments resulted in adults emerging after 11 – 19 days.

2.5 Insect sampling for crop loss assessment

Different activities of insects such as their population on the crop, damage inflicted to plants and insect stages present were surveyed on each plot.

2.5.1 Direct Assessment

Direct assessment of the number of insect on the crops randomly selected from each plot was taken. The number of bugs was counted per panicle. The stems and the roots were also cut open to determine the number of larvae. The number insects in each species which were knocked down on the beating sheet was recorded versus the area surveyed (Saini, 2011).

2.5.2 Indirect assessment

The difference between incidence (number of damaged plants) and intensity or severity (degree or extent of damage) in each plot was recorded.

Holes, spots, mines, rolls or epidermis removal indicate attack by leaf caterpillars, leaf miners or leaf beetles and this damage was recorded as scores by approximating the area damaged versus the undamaged area (Saini, 2011). Crop loss can be defined as the difference between the potential yield Y (p) (the yield that would have been obtained in the absence of the pest under the study) and the actual yield Y (a). It is convenient to express this proportionate to the potential yield, to obtain a proportional crop loss r (Odendo *et al.,* 2003).

$$r = \frac{y_p - y_a}{y_p}$$

Formula 1: Calculation of yield loss where *r* is the crop yield loss as a result of pest damage

2.6 Data Analysis

The data was tabulated in excel worksheets where the mean number of infestation in all the treatments was be compared using Analysis of Variance (ANOVA). The damage and the number of pests were given scores/rated and this scores were log transformed and analyzed. All significantly different treatments were separated using the Student least significant difference (LSD) (SAS Institute, 2009) at 0.05 significance level.

3.0 Results

A total of 1256 insect specimens were collected from amaranth during the period April2012 and April 2013. The pest species were grouped into five orders, 15 families and 33 species (Table 1). The order with the greatest number of species was Heteroptera with 13 species, followed by coleopteran with 11 species. The pests were further grouped into two large groups: the stem and leaf pests and the grain pests. The most damaging grain pest were the *Cletus sp.* (Heteroptera) causing upto 40% grain loss (Table 3). *Hepertogramma bipunctalis* (Coleoptera) feeds on the stems and leaves causing upto 27% foliage yield loss. Another significant pest that causes damage on stem and foliage was *Hypolixus nibiloscus* (Coleoptera).

The insect with potential of being conserved as natural enemies and parasitoids that were collected on amaranth were classified into two orders (coleopteran and Hymenoptera), five families and 8 species (Table 2). The results also show that there was significant yield loss of both the grain and leaf which are the harvestable parts of amaranth in the region (P-value: 0.00019, 5 and 12 df, N: 18).

4.0 Discussion

The results from this study show diversity in the number of insect species associated with cultivated amaranth in Meru County. These results concur with the findings from similar survey carried out in Puebla, Mexico (López *et al.*, 2011). From the results Heteroptera is the order with greatest number of species, that is, 13 species, which causes significant damage to grains. The most significant genera in this Order was *Cletus* with four species. This genera was the most occurring with infestations of 100% in all plots. These insects are observed mostly at the beginning of milking stage and the population increases as the grain matures (Figure 1). This was also observed by Oke and Ofuya (2011) in their study on amaranth in Ibadan, Nigeria. They observed that the population of *Cletus sp.* increases gradually from the start of milking stage to maturity, with the highest population being recorded slightly before harvesting.

White grabs of *Hepertogramma bipunctalis* (Lepidoptera) were isolated from 60% of the stems that were sampled and dissected. The grabs tunnel through the stem leaving behind gallaries and exit holes which are used for escape when the adult emerges. The gallaries and exit holes make the stem weak and if the weather is windy it causes lodging of the crop resulting to yield loss if the crop is not yet mature. If the weather is not windy the crop continues to grow without significant loss on yield. Oliveira *et al.* (2012) observed that 100% of the crop examined presented galleries of up to 5mm in diameter throughout the main stems which was an indication of the presence of *H. bipunctalis* larvae. This larvae was also observed feeding and building galleries in stems of amaranth in Puebla, Mexico (López *et al.,* 2011).

From this study both the larvae and adults of *Hypolixus nubilosus* (Coleoptera) caused significant damage to the crop. The adults puncture holes in the leaves while feeding and the females oviposit in the stems where eggs hatch into larvae which feed while tunneling through the stem. This pest resulted to significant crop loss especially through foliage damage. This pest has also been reported to cause considerable damage on amaranth leaves and stems in Mexico (Torres *et al.,* 2011 and López *et al.,* 2011).

Most Hymenopterans and some coleopterans observed in this study can be classified as natural enemies or parasitoids of amaranth pests. *Dentichamias busseolae* which was sampled during the second season of planting has been reported as a larvae parasitoid of lepidopterans. Braconid parasite (Bracon sp.) was also observed occurring on amaranth in Mexico (López *et al.*, 2011). This is the first study in Kenya which has reported the naturally occurring enemies and parasitoids of amaranth insect pest.

5.0 Conclusion

From this study we can conclude that there is a diverse number of insect species occurring in cultivated amaranth in Meru County, Kenya. The pests causing significant yield loss are coreid bugs (*Cletus sp.*) which attacks the grain, Amaranth weevil (*Hypolixus nubilosus*) which causes damage on stems and leaves and Webworm (*Hepertogramma bipunctalis*) which also attacks stems and leaves. The pests results to significant yield loss on both the grain and leaves which are the harvestable parts of amaranth in this region. A considerable number of naturally occurring enemies and parasitoids were collected indicating there is potential to conserve these insects for biological control.

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Tables and Figures

Table 1: List of insect pests sampled from amaranth between March 2012 and April 2013 in Meru County, Kenya

Order	Family	Scientific Name	Common Name
Coleoptera	Baridinae	*Baris massaica*	Stem-girdling Weevil
	Curculionidae/Cleoninae	*Hypolixus nubilosus*	Amaranthus Weevil
	Tenebrionidae/Lagrinae	*Lagria sp.*	Darkling Beetle
	Curculionidae	*Nematocerus sp.*	Shiny Cereal Weevils
	Coccinellidae	*Exochomus ventralis*	
	Coccinellidae	*Hippodamia variegate*	
	Cantharidae	*Lycus constrictus*	
	Cantharidae	*Idgia fulricollis*	
	Staphylinidae	*Paederus sabaeus*	
	Apionidae	*Apion africanum*	
	Chrysomelidae	*Strobiderus africanus*	
Hemiptera	Redunidae	*Rhinocoris segmentalis*	Assassin bug
	Pentatomidae/Scutellarinae	*Sphaerocoris annulus*	Shield-backed Bug
	Coridae	*Cletus indicator*	Horned Coreid Bug
	Pentatomidae	*Nezera virudala*	Green Stink Bug
	Pentatomidae	*Menida maculiventris*	
	Pentatomidae	*Agonoscelis versicolor*	
	Coreidae	*Cletus orientalis*	Horned Coreid Bug
	Coreidae	*Cletus capensis*	Horned Coreid Bug
	Pentatomidae	*Nysius binotatus*	
	Tingidae	*Dictyla nodipennis*	
	Coreidae	*Cletus ochraceus*	Horned Coreid Bug
	Miridae	*1 spp.*	
	Miridae	*Eurystylus spp.*	
Lepidoptera	Pyralidae	*Herpetogramma spp.*	Beet webworm
Orthoptera	Pyrgomorphidae	*3Sp.*	Grasshopper

Table 2: List of beneficial insects sampled from amaranth between March 2012 and April 2013 in Meru County, Kenya

Order	Family	Scientific Name	Common Name
Coleoptera	Coccinelidae	*Cheilomenes sulphurea*	
	Coccinelidae	*Cheilomenes lunata*	Lunate Ladybird
	Coccinelidae	*Cheilomenes vicina*	
	Coccinelidae	*Cheilomenes propinqua*	
Hymenoptera	Ichneumonidae	*Dentichasmias busseolae*	Hymenoptera
	Braconidae	*Iphiulax varipalpis*	Braconid Parasite
	Sphecidae	*Philanthus triangulum*	Bee wolf
	Sphecidae	*Dolichurus spp.*	

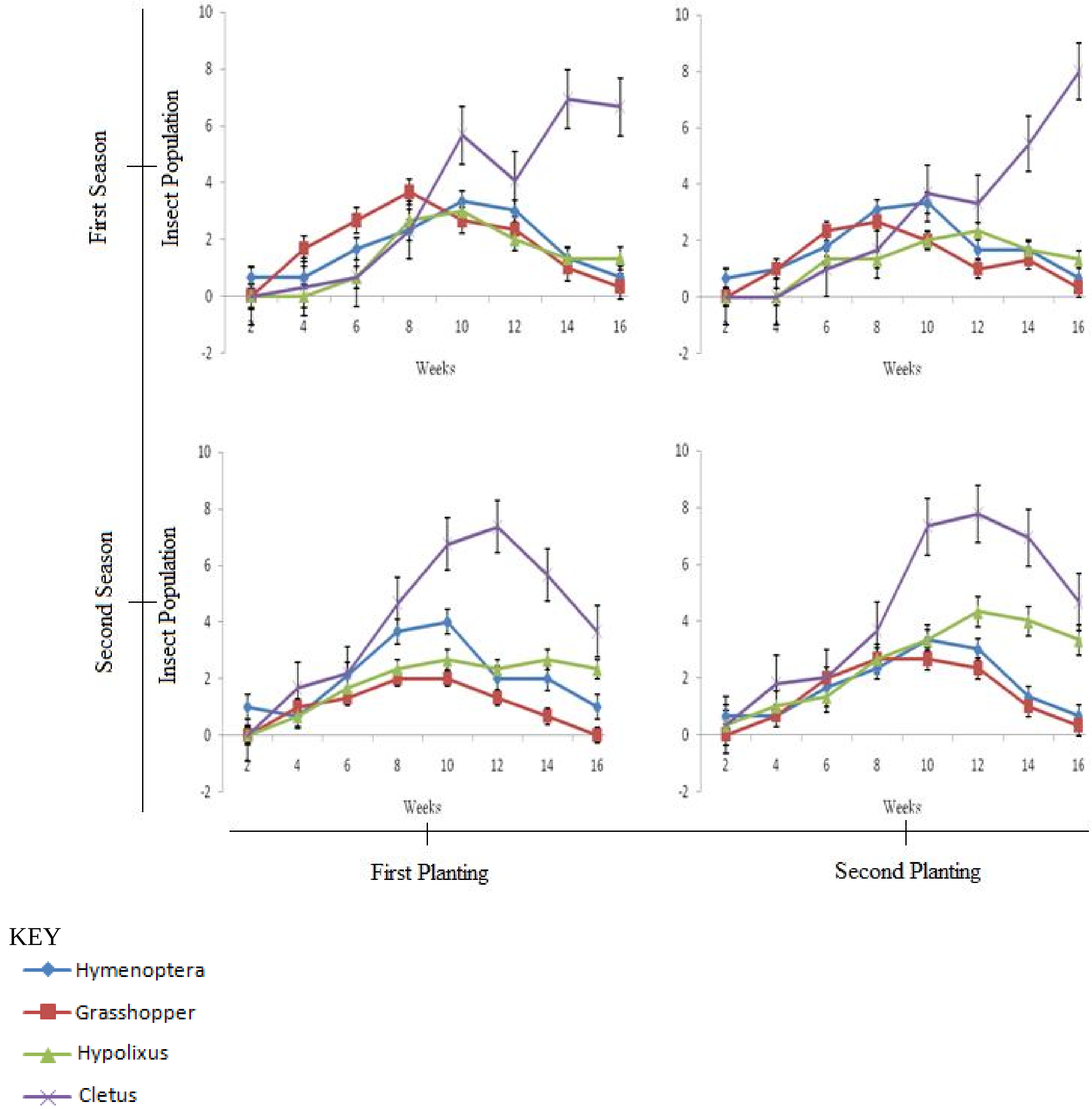

Figure 1: Population trends of insects associated with amaranth in relation to planting dates and seasons between April 2012 and April 2013.

Table 3: Means of production of amaranth grain under different treatments and analysis of losses due to pests of amaranth, as a function of the treatments in Meru County, Kenya.

TREATMENT	ACTUAL YIELD (Ya)	POTENTIAL YIELD (Yp)	YIELD LOSS ®	PERCENTAGE YIELD LOSS
A. cruentus 1st Planting	0.3757±0.0164	0.5000	0.2487±0.0329[c]	24.87
A. cruentus 2nd Planting	0.2507±0.0288	0.5000	0.4987±0.0574[b]	49.87
Neem extract	0.3863±0.0080	0.5000	0.2273±0.0160[a]	22.73
Chemical treatment	0.4210±0.0030	0.5000	0.1580±0.0060[a]	15.80

Table 4: Means of production of amaranth leaves under different treatments and analysis of losses due to pests of amaranth, as a function of the treatments in Meru County, Kenya.

TREATMENT	ACTUAL YIELD (Ya)	POTENTIAL YIELD (Yp)	YIELD LOSS ®	PERCENTAGE LOSS
A. cruentus 1st Planting	0.4889±0.0123	0.8	0.3892±0.0154[c]	38.92
A. cruentus 2nd Planting	0.4600±0.0020	0.8	0.4250±0.0025[c]	42.50
Neem extract	0.5663±0.0120	0.8	0.2921±0.0150[b]	29.21
Chemical treatment	0.6977±0.0180	0.8	0.1279±0.0224[a]	12.79
A. dubius 1st Planting	0.5933±0.0071	0.8	0.2583±0.0089[a]	25.83
A. dubius 2nd Planting	0.5640±0.0078	0.8	0.2950±0.0098[b]	29.50