African Journal of Food Science and Technology ((ISSN: 2141-5455) Vol. 5(1) pp. 6-11, January, 2014
DOI: http:/dx.doi.org/10.14303/ajfst.2014.007
Available online @http://www.interesjournals.org/AJFST

Full Length Research Paper

Phytogeography of stem borer species of *Zea mays* L. and *sorghum bicolor* l. and their refugia graminae

Robert W. Nyukuri*[1], Stella C. Kirui[2], Everlyn Cheramgoi[3], Elizabeth Chirchir [1] and Ruth Mwale[4]

[1]Department of Biological Sciences, School of Science, University of Eldoret, P.O.Box 1125, Eldoret, Kenya.
[2]Department of Biological Sciences, School of Science, Maasai Mara University, P.O.Box 861, Narok, Kenya.
[3]Crop Improvement Programme, Integrated Pest and Disease Management (IPDM) Section, Tea Research Foundation of Kenya (TRFK), P.O. Box 820-20200, Kericho, Kenya.
[4]Department of Biological Sciences, Rongo University College, 103-40401, Rongo.
*Corresponding Author Email:rnyukuri@yahoo.com

ABSTRACT

This study aimed at determining the phytogeography of stem borer species of *Zea mays* L. and *Sorghum bicolor* L. and refugia graminae. It involved two growing gramineous crops: maize *Zea mays* L. and *Sorghum bicolor* L. and three gramineous forages: Napier grass *Pennisetum purpureum* Schumach, Sudan grass and giant Setaria grass. These were planted both in pure and mixed stands and sampling for the borer infestation done throughout the phenology of crops . Three stem borers were recorded: *Busseola fusca* (Fuller), *Chilo partellus* (swinhoe) and *Sasemia calamistis* (Hampson).The *B.fusca* was more abundant in highlands (15 borers/10 plants with 1.5$\pm$ 0.6 larvae/plant) at 9 weeks after emergence (WAE). The *C. partellus* predominantly featured in lowlands with (22 borers /plant and 2.2 $\pm$ 0.8 larvae/ plant) at 7 WAE. This was punctuated with the S. *calamistis* in the later habitat. However, on the overall, *B. fusca* was the most prevalent with a mean of 11.20 while *S. calamistis* had the least prevalence with a mean of 2.000.*B.fusca* was the most prevalent species in the highlands while *C.partellus* was the most abundant species in the lowlands and *S.calamistis* was scanty. More research should be conducted to determine the strains of *B.fusca,C.partellus* and *S.calamistis* as initially,these species had distinct ecological zones.However,they are currently found in various ecozones.Molecular techniques can be employed in characterize them for identity.

Keywords: Phytogeography, stem borer,Zea mays L.,Sorghum bicolor,refugia and graminae

INTRODUCTION

About 50 species of maize and many sorghum environmental biotypes exist and consist of different colors, textures and grain shapes and sizes. White, yellow, brown and red are the most common types. The white and yellow colours of maize while the dark brown, red brown and white sorghum are preferred by most people depending on the region (Chabi-Olaye *et al.,*2004).

Maize is the leading staple food in the world with two –thirds of the global proportion of the area grown in sub Saharan Africa developing countries (Ahmad *et al.,*2000). Both maize also called corn and sorghum are among the most crucial and strategic cereal crops in the world and especially in the developing countries of Africa, Asia and South America (CIMMYT and IITA,2010). It is produced in different parts of the continents under diverse climatic and ecological conditions(Blum,2005).

The ICRISAT (2006), and national program partners in Asia and sub-Saharan Africa, assessed the 'spillover' potential of sorghum varieties and hybrids. This aimed to find out how successful these varieties were in areas outside those that they were originally bred for. It has often been argued that, in heterogeneous environments, returns on the investment in breeding new varieties will be low, because new cultivars will tend to perform well in only the locations that they were initially bred for

(Muthoka,2006). However, the study demonstrated that this was not the case. In fact, cultivars originating from collaborative national and international research can prove to be highly transferable across different environments (Kingi and Burgress, 2004;Nyukuri *et al.*,2012).

For example, improved varieties occupy approximately 36% of Tanzania's sorghum area. They are widely popular, mainly for their early maturity (and thus drought tolerance) and high yield – 10–38% higher than local varieties. Adoption has been stimulated by interventions by ICRISAT and local partners to strengthen local seed systems and community-based seed production (AATF, 2012).

Both maize and sorghum production in this continent are rain fed. Irregular rainfall can trigger famines during occasional droughts. According to 2011 FAO estimates, 188 and 150 million hectares of maize are harvested worldwide. Africa harvests 29 million hectares, with Nigeria, the largest producer in SSA, harvesting 5% of maize followed by Tanzania (ICRISAT,2006).

Since a greater proportion in the patterns of change in maize production is explained by extensification rather than intensification, maize policy development in Africa needs to place greater emphasis on the development and dissemination of productivity-enhancing technologies. It is against this background of understanding that this study was conceived. The objectives of this study were to determine the composition of stem borer species, their phytogeography and to quantify their population dynamics in maize, sorghum and forage graminae refugia intercrops.

MATERIALS AND METHODS

Study Site

This study was conducted in Kenya Agricultural Research Institute (KARI), at Kitale Centre situated at latitude 1°01' N, longitude 35°7.5'E, at an elevation of 1,890 masl. It receives on average 1,143 mm annual rainfall and the soils are loamy. The centre is in Trans-Nzoia County, Kitale west district and is located 3km west of Kitale town. The Trans-Nzoia County is a continuation of the fertile Uasin Gishu Plateau beyond ("trans") the Nzoia River. The rainfall is bimodal occurring in two seasons. March to June/July and the second rain starts indistinctly around July to November. The rainfall peaks are at the end of April and end of July/August. The temperatures are relatively low due to high altitude and proximity to Mt. Elgon and Cherang'ani hills with average daily temperature of 22.5± 2 ^{0}C.

Experimental design and layout

The field under which studies were conducted was provided by KARI administration. As rainfall is bimodal, the duration of the trial was tagged to the 2011 long rain during the main cereal cropping season. A completely randomized block design with three replications of five treatments was used. Each plot measuring 6X6m with avenues of about 0.5 between plots were maintained to ensure accessibility and facilitate daily operations during the duration of the experiment.

The study applied a survey method to investigate the phytogeography and taxonomy of stem borer species of maize, *Z. mays* L. and sorghum, *S. bicolor*, Sudan grass, Napier grass, and giant setaria grass. The plots were planted at the beginning of the rains with commercial cultivar of hybrid maize H622 from Kenya Seed Company Ltd, local sorghum 9 red, Sudan grass, Napier grass Kakamega 1, KI and giant Setaria were obtain from KARI. Data was accumulated from the five treatments listed under various experiments as below:

Pure cropping agro - ecosystems geography

These consisted of: Three plots of 6x6m of maize with inter-row spacing of 75cm and inter-plant 30cm, three plots of 6x6m of sorghum drilled with an inter-row spacing of 45cm and thinned to 15cm intra-row spacing, three plots of 6x6m of Sudan grass drilled with an inter-row spacing of 45cm and thinned to 15cm intra-row spacing, three plots of 6x6m of Napier grass KI with inter-row spacing of 60cm and inter-plant 60cm and three plots of 6x6m of giant Setaria with inter-row spacing of 60cm and inter-plant of 60cm.

Mixed stands/ intercropped agro – ecosystems geography

These consisted of: Three plots of maize with inter – row of 75cm and inter-plant spacing of 30cm intercropped with Napier grass with inter – row 30cm and inter- plant 30cm spacing, three plots of maize with an inter – row of 75cm and inter – plant 30cm intercropped with Sudan grass inter – row 30cm and thinned to 20cm inter – plant, three plots of maize with inter – of 75cm and inter – plant of 30cm intercropped with giant Setaria grass inter – row 30cm and 30cm inter – plant spacing, three plots of sorghum drilled with an inter- row spacing of 45cm and thinned to 15cm inter-plant intercropped with Napier grass with inter – row and inter – plant spacing of 30cm, three plots of sorghum drilled with inter – row of 45cm and thinned to 15cm inter- plant spacing intercropped with Sudan grass of 30cm and 20cm spacing of inter- row and inter- plant spacing respectively and three plots of sorghum drilled with an inter- row spacing of 45cm and thinned to 15cm inter-plant intercropped with giant Setaria grass of 30cm inter- row and inter-plant spacing.
Fully established and grown phytogeographical patterns were as depicted in plates 1 – 5 below:

Plate 1. Experimental plot of maize showing drying of leaves due to stem borer damage

Plate 2. Experimental plot of matured sorghum

Determination of stem borer species taxonomy and population dynamics

In order to determine species composition in maize, 10 plants were sampled at fortnightly intervals from plots and assessed for borer infestations between 2-12 weeks after emergence (WAE).This was done for 6 weeks. At harvesting, destructive sampling was carried out on 10 plant samples per plot. Every plant was dissected and the larvae obtained were counted and recorded. Each larval insect recovered from the plants was identified using standard stalk borer distinctive features. In this regard, colour, body spotting of larvae, sizes and colour of pupae were employed. Similar procedures were adopted on samples collected from farmers' fields with sampling initiated when plants were two weeks old after emergence (2WAE) and continued throughout the phenology of the cropping. At harvesting, 10 plants per

Plate 3. Experimental plot of Sudan grass at flowering stage

Plate 4. Experimental plot of luxuriant Napier grass,k1.

Plate 5. Experimental plot of giant Setaria grass nearing harvesting

plot were sampled and dissected and the insects recovered in them were identified at Museum following Leo's protocol (2005).

However, for sorghum, Napier grass KI, giant Setaria and Sudan grass, the complexity of their attack in relation to plant phenology was determined by survey mainly

Table 1. Interrelationship of stalk borer species and age of maize plants from two ecological zones

Highlands			Lowlands		
Plant age	Mean Borers / plant (±SE)	Borer Species	Plant age	Mean Borers/ plant (+ SE)	Borer species
2 WAE	0.0	-	3 WAE	0.6 ± 0.1	*C. partellus*
4 WAE	0.0	-	5 WAE	0.4 ± 0.2	*C. partellus*
6 WAE	0.4 ± 0.2	*B.fusca*	7 WAE	2.2 ± 0.8	*C. partellus*
8 WAE	1.0 ± 0.3	*B.fusca*	9 WAE	1.5 ± 0.6	*C. partellus*
	0.6 ± 0.3				*S. calamistis*
10 WAE	0.9 ± 0.5	*B.fusca*	11 WAE	0.9 ± 0.3	*C. partellus*
			0.4 ± 0.2		*S. calamistis*

Table 2. Prevalence of stem borers in maize, sorghum and graminae refugia hosts

B.fusca	Maize	Sorghum	Grasses	Mean	Std Dev	Std error
1	18.3^{a}	9.7^{a}	6.3^{a}	11.2	3.834	1.715
2	17.4^{a}	8.1^{a}	5.9^{b}			
3	14.3^{b}	12.6^{b}	5.7^{b}			
4	15.1^{b}	10.3^{b}	6.4^{a}			
5	16.1^{c}	15.3^{c}	6.7^{c}			
C.partellus						
1	10.2^{a}	4.6^{C}	0.9^{b}	4.80	3.271	1.463
2	3.4^{b}	8.7^{a}	2.7^{a}			
3	5.6^{b}	2.3^{b}	1.8^{a}			
4	6.1^{C}	5.6^{c}	1.6^{a}			
5	10.7^{a}	4.8^{c}	5.0^{c}			
S.calamistis						
1	3.3^{b}	2.3^{a}	1.5^{b}	2.00	2.000	.894
2	2.6^{a}	3.1^{b}	0.7^{a}			
3	3.7^{b}	0.6^{c}	1.8^{b}			
4	0.3^{C}	0.7^{C}	0.4^{a}			
5	5.1^{b}	2.3^{a}	0.6^{a}			

concentrating on the experimental plots as described in preceded study and additional samples were taken from 10 pre-selected farmers from each of the three districts in Trans-Nzoia County.

The survey started from the fiftieth day after emergence (DAE) and continued until the Napier, Sudan grass and giant Setaria were matured and harvested. Randomly 10 plants with exit holes and frass were destructively sampled in each plot to recover the stem borers. Representatives of the stem insects damaging sorghum, Napier, giant Seteria and Sudan grass were preserved and reared in the laboratory to adult stage.

RESULTS

Quantification of species composition of stalk borers of gramineous hosts in Highlands and lowlands

In the highlands of Trans-Nzoia County such as Mt. Elgon and Cherang'ani Hills, *B. fusca* was the only stalk borer identified that attacked maize crops at 6 weeks after emergence (WAE). By then, the maize crop was about the sixth leaf stage. However, infestation was generally low (Table 2). At initiation, approximately 4 borers/ 10 plants (0.4 ±0.2 larvae/ plant) were recorded. The population increased four-fold at 12 WAE when 15 borers/ 10 plants (1.5 ± 0.6 larvae/ plant) were recorded. Infestation lasted till harvesting when *B. fusca* borers were recorded from both maize stems and cobs. At lowlands of the County, the predominant borer was the spotted stalk borer *C. partellus* (Table 1). The borer attacked the crops from 3 WAE initially with a population of 6 borers/ 10 plants (0.6 ± 0.1 larvae/ plant). This rose phenomenally by four-fold to 22 borers/ 10 plants (2.2 ± 0.8 larvae/ plant) at 7 WAE. Two weeks later, (9 WAE), the *S. calamistis* invaded the fields and attacked maize together with *C. partellus*. However, the population of the former species was low till harvesting time. There were no recorded attacks on cobs by both borer species.

Quantification of the population of stem borers in maize, sorghum and potential refugia

The *B. fusca* species was the most prevalent stem borer in the hosts with a mean of 11.20 stem borers. It was followed by *C. partellus* which had a mean of 4.80 stem borers. The *S. calamistis* species was the least prevalent with a mean of 2.00 stem borers (Table 2).

DISCUSSION

The studies established the phytogeography and quantified the culprit pests. The stem borers that can be controlled by growing different potential refugia graminae in mixtures with maize and sorghum in any of the zones differed as observed by Mulaa *et al*.,(2011). *B. fusca* and *C. partellus* were the stem borer species identified in maize, sorghum, Napier grass, Sudan grass and giant Setaria when grown in highland and the lowland regions of the county respectively. In the latter site, there was a near negligible incidence of *S. calamistis* meaning it was rather sporadic elsewhere due to altitudinal isolation (Aziz *et al*.,). The two borer species were more prevalent than the latter and showed distinct agro-ecological zone preference. This has been the observed trend since the last two decades (De Grote, 2002; Bandlerova,2013). The altitude seemed to have led to the apparent observed distribution, with *B. fusca* preferring the highland areas and *C. partellus* occurring in the lowland areas. The relative stability in the areas of occurrence of those species was due to the altitudinal adaptations and affinities which lacked in the *C.partellus* species which had not upsurged into their endemic areas (Khan *et al*., 2013). The stability in the pest status could have also been due to lack of changes in agronomic practices effected over the period to either enhance or empede the species spread as changes in cultural practices over long durations may ultimately alter pest status (Charcosset and Horst,2005). If their stability had invariably varied, this implied that appropriate agronomic practices had to be devised and synchronized to production regimes to enhance yields.

Species diversity had not drastically altered meaning that continuous growing of maize and sorghum in juriposition with Napier, Sudan and giant Setaria grasses has led to highly variable regimes of survival and development of stem borers (Maddoni *et al*.,2006).

CONCLUSION

The study showed that three stem borers exist the region, of these the *B.fusca* is the most abundant species and predominantly occupies highlands while C. *partellus* species occupies mainly the lowlands. However, the occurrence of *S. calamistis* is in lowlands and is scanty.

REFERENCES

AATF (African Agricultural Technology Foundation), 2012. Project 4: Water Efficient Maize for Africa (WEMA).Website:http://www.aatf – frica.org/userflies/WEMA – brief.

Ahmad NA, Waheed M, Hamid FS(2000).Perfomance of maize cultivars under late sowing conditions.Pak.J.Biol.Sci.3(12):2098 – 2100.

Aziz AM, Saleem H, Rehman, Muhammad F(2013).Perfomance of maize hybrids under irrigated conditions.Sarhad J.Agric.8(5):509 – 512.

Bandlerova, G,H. (2013). The Lepidopterous stalk borers associated with Graminae in South Africa. Bull. Entomol. Res .49:367-383.

Blum A(2005). Drought resistance, water use efficiency and yield potential – are compatible, dissonant or mutually exclusive? Australian J. Chabi–Olaye,A.,Schulthess,F.and Borgemeister,C.(2008).Effects of nitrogen and potassium combinations on yields and infestations of maize by *Busseola fusca* (Lepidoptera:Noctuidae) in the humid forest of Cameroon.*Journal of Economic Entomology* 101,90 – 98.

Charcosset A, Horst WS(2005).The calculations of the dosage-mortality curve. Ann. Appl. Biol. 22:134-167.

CIMMYT and IITA. (2010). MAIZE – Global alliance for improving food security and the livelihoods of the resource-poor in the developing world. Draft proposal submitted by CIMMYT and IITA to the CGIAR Consortium Board. El Batan, Mexico. 91 pp and IITA to the CGIAR Consortium Board. El Batan, Mexico. 91 pp.

De Groote H(2002).Maize yield losses from stem borers in Kenya.Insect Sci.Appl.22:89 – 96.

ICRISAT,(2006).Sorghum Contribution to good nutrition.http://www.icrisat.org/test.

Khan MA, Akbar S, Ahmad K, Baloch MS(2013).Evaluation of corn hybrids for grain yield. Pak.J.Biol.Sci.2(2):413 – 414..

Kingi FA, Burgess PF(2004). A guide to the biology and control of pests of field crops and stored produce in Kenya.Min. of Agric. Rep. of Kenya.

Leo RT(2005). Stem borers of cereal crops at Kongwa, Tanganyika, 1950-52. E. Afr. Agric. For. J. 19: 105-106.

Maddonni GA, Alfredo GC, Otegui ME(2006).Insect host plant relationship: the spotted stalk borer *Chilo partellus*(Swinhoe) (Lepidoptera: Pyramidal) and its principal host sorghum. Insect Sci Applic. 6, 315-322.

Mulaa MM, Bergvinson JD, Mugo SN, Wanyama JM, Tende RM, De Groote H, Tefera TM(2011).Evaluation of stem borer resistance management strategies for Bt maize in Kenya based on alternative host refugia.Afr.J.Biotechnol.10:4732 – 4739.

Muthoka DM, Nduati NM, Maina NM, Kamau EM(2006).Quality and Market access:The case study of hybrid maize.Nairobi.Macmillan Publishers Limited.pp 7.

Nyukuri RW, Wanjala FME, Cheramgoi E, Odhiambo J, Kirui S(2012).Effects of Different Agroecosystems on Prevalence of Different Species of Pests and Coccinellid Predators.In:Agricultural Science and technology.PP 776 – 783.

How to cite this article: Nyukuri R.W., Kirui S.T., Cheramgoi E., Chirchir E. and Mwale R. (2014). Phytogeography of stem borer species of *Zea mays* L. and *sorghum bicolor* l. and their refugia graminae. Afr. J. Food Sci. Technol. 5(1):6-11