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Original Research Article

SPECIES COMPLEX AND ABUNDANCE OF PANICLE INSECT PESTS OF SORGHUM *(Sorghum bicolor* (L.) (MOENCH) AT YOLA AND KALTUNGO IN THE NORTH EASTERN NIGERIA

ABSTRACT

Species complex and abundance of panicle insect pests of sorghum was studied on eight sorghum varieties and cultivars in field trial conducted at Yola, Adamawa State and Kaltungo, Gombe State in 2012 cropping season. The experiment was laid using randomized complete block design (RCBD) which was replicated 3 times in $12m^2$ plots consisting of eight sorghum varieties/cultivars. Data was collected as from Complete Anthesis Stage (CAS) in September up to Hard Dough Stage (HDS) of sorghum development in November ending. During this trial, eighteen different insects were identified during the study at both Yola and Kaltungo. At both locations three insects differs each. Insects identified in order of their abundance were: *Eurystylus oldi* (Poppius), *Sitophilus zeamais* (Motschulsky), *Monolepta* sp., *Orius* sp., *Nola sorghiella* (Rilley), *Agnoscelis versicola* (Thumberg), *Mirperus jaculatus* (Thumberg), *Spilostethus* sp. (Stal), *Nezera viridula* (Linnaeus), *Campylomma* sp. (Odhiambo), *Achaearanea tepidoriorum, Forficula senegalensis* (Serville), *Apis mellifera, Messor* sp. (Emery), *Erythroneura variabilis, Poophilus costalis* (Walker), *Apocrita polistes, Kraussaria angulifera* (Krauss), *Pachnoda chordata* (Olvier), *Mantids religiosa* and *Silidius apicalis*. The variety that haboured the highest population of insect pests was SAMSORG-17 at Yola with a mean population of (609.68/10 panicles) and the least was on Tiksha-Mamza (Ex-Garkida) with a population of (153.33/10 panicles). At Kaltungo, it was SAMSORG-14 haboured the highest population of panicle insect pests (834.34/10 panicles) and the least was on Ex-Tula Farafara cultivar (182.34/10 panicles).The cultivars habours less insects and are more promising than the Samsorg improved varieties that habours more insects.

Keywords: Species complex, Panicle, Tiksa-Manza, Ex-Tula, Samsorg, Insects

INTRODUCTION

Sorghum (*Sorghum bicolor* (L) Moench) belong to the family Poaceae and originated in Africa which is the fifth world most important crop after wheat, rice and barley (1, 2, 3). Millions of people of the semi – arid tropic especially in Africa, Asia and India depend on sorghum as a staple food (4). Sorghum is being faced with important problem that result to large yield losses caused by parasitic weeds (especially *Striga hermonthica*) anthracnose ,downy mildew, grain moulds, sorghum midge and stem bores (5). The crop is attacked by a wide and complex range of insect pests worldwide and the total pests load in any area can be very heavy. In spite of the importance of the crop there are few reports on different aspects of sorghum insect pests; progress has been low because of the perceived low market value of the sorghum in developing countries (6, 2, 3). Insect pests are a major constraint to increased sorghum production in West Africa, with over 100 species recorded, of which more than 40 are panicle – feeding pests (8, 9, 10, 11, 12). In Nigeria, insect pests attacked sorghum at virtually all phonological Stages.

UNDER PEER REVIEW

However, only a few of the these are considered to be economically important pests in West Africa, among which are stem borers, Sorghum midge, shoofly, spittle bugs and a complex of pentatomid and mirid head bugs (13,14,15,2,16,12). Panicle infesting insects, feed directly on the reproductive parts of cereal, they often cause direct and irreversible damage (16). Malgwi and Ajayi (2011), further stated that, in Africa, there are few isolate report which have been documented more specifically on head bugs, but no detailed report on the species complex and their abundance. However it is believed that improved varieties hold a key to increased and sustainable sorghum production because they combine early maturity with higher yield and have better potential for commercial exploitation and industrial use than the local cultivars. Therefore the need to develop effective management practices for panicle feeders cannot be over emphasized (11).

This paper, reports on species complex and abundance of panicle insect pest on different sorghum varieties and cultivars, with the aim of suggesting some peak period of abundance and when to escape high damage which could be incorporated in integrated pest management.

MATERIALS AND METHODS

Trials were established at the teaching and research farm of the Department of Crop Protection, Modibbo Adama University of Technology Yola and Kaltungo, Gombe state. Yola is located within latitute $9^0$11'N to $9^0$19"N and longitude $12^0$31'E (17) and Kaltungo is located within latitude $9^0$48'N to $9^0$51'N and longitude $11^0$18'E to $11^0$32'E (18) both in Guinea savanna zone of Nigeria during 2011 cropping season.

Sorghum Varieties and Cultivars; Experimental Design

Eight varieties and cultivars of sorghum were obtained from three sources. Five of the varieties (SAMSORG-41, SAMSORG-14, SAMSORG-17, SAMSORG-37 and SAMSORG-39) were obtained from the Institute for Agricultural Research (IAR) /Ahmadu Bello University (ABU) Samaru, Zaria, one cultivar Tiksha Mamza (Ex-Garkida) was obtained from Garkida and two cultivars (Ex-Tula Red Cultivar and Ex-Tula Farafara) were obtained from Tula. This varieties and cultivars characteristic has already been described and discussed (19, 20),

The experiment was laid out in a randomized complete block design (RCBD) replicated three times with eight varieties and cultivars of sorghum as the treatments. Each replication was separated by 2m apart and inter plot spacing was 1.5m while the plot size was 3x4m^2 (12m^2). The intra-plot spacing was 0.4m and inter-plot spacing was 0.75m.

UNDER PEER REVIEW

Cultural practices

The fields were ploughed with a tractor mould-board plough. The fields were later marked out as earlier mentioned. Apron star 50 DS (Metal-axyl 10%, carboxin 6% +furathiocarb 34%) at the rate of 1 sachet per 10 kg of seed was used to dress the seeds before planting. The seeds were sown on 24th June at Yola and 28th June at Kaltungo in 2011 for effective data collection. The seeds were sown at the rate of 4-6 per hole in a depth of 2cm. The plants were later thinned to 2 plants per stand at two weeks after emergence. Split application of fertilizer NPK 15:15:15 was applied at four and eight weeks after emergence at the rate of 64 kg Nha^{-1}. Manual hoe weeding was carried out two times depending on the weed infestation and followed by molding-up of earth around sorghum stands in order to prevent lodging of the sorghum plants.

Data collection and analysis

Sampling and insect data collection was carried out in the morning hours (06:00-08:30hrs) when the insects were at rest or inactive. The date of the Sampling varied with the varieties and cultivars depending on the date of flowering, maturity and location. This was done on weekly basis from September to November ending (from CAS to HDS of sorghum development) in each location there was 48hours to allow effective data collection. Species composition and panicle insect pests count was carried out using polythene bags size measuring 54cm length and 36 cm widths was used as described earlier by 21,22,12). Ten (10) panicles were sampled per plot at random on a weekly basis and the insects were collected by shaking each panicle vigorously into polythene bags. The insects were immobilized using chloroform on a cotton wool swab and the contents were sorted out and counted in the laboratory and recorded and identification of insect was done with the help of insect reference boxes. The data obtained on the eight sorghum varieties and cultivars were subjected to Analysis of Variance (ANOVA) using (23) 12 Software Version 8 (2) and Student-Newman-Keuls (SNK) was used to separate the means at $p = 0.05$ test for variables.

RESULTS

The result for the species complex for both locations (Yola and Kaltungo) showed that 21 species of insects were identified. (*Monolepta* sp., *Spilostethus* sp. (Stal), *Eurystylus oldi* (Poppius), *Nola sorghiella* (Riley), *Agnocelis versicola* (Thumberg), *Compylomma* sp. (Odhianbo), *Erythroneura variabilis, Mirperus jaculatus* (Thumberg), *Messor* sp. (Emery), *Pachnoda chordata* (Olivier), *Sitophilus zeamais* (Motschusky), *Poophilus costalis* (Walker), *Kraussaria angulifera* (Krauss), *Nezara viridula* (Linnaeus) and *Silidius apicalis*) are pests; (*Achaearanea tepidariorum, Orius* sp., *Forficula senegalensis* (Serville) and *Mantids religiosa*) are predators and (*Aphis millifera)*

UNDER PEER REVIEW

and (*Apocrita polistes*) are pollinators (Table 1 and Plates 1-21). *A. polistes* though a pollinator, but is also a pest because it was found feeding on developing grains and deposit some exudates which leads to growth and development of mould on grains.

The result showed that, weekly population trend of panicle insect pests in the two locations (Yola and Kaltungo) differs slightly. At Yola, it was the 7th week (24 October) that had the highest population of insect pests (60.50), the lowest population of insect pests was recorded in the 12th week (28 November) (0.75) while at Kaltungo the highest population was recorded in the 6th week (17 October) (100.38) and supported with the lowest population in the 11th week (21 November) (1.46). When the two locations were combined, it was the 6th week (17 October) with the highest population of about 74.65 and supported with the lowest in the 12th week (28 November) with 1.45 (Table 2).

The mean cumulative insect pests on the eight sorghum varieties and cultivars in 2012 cropping season in the two locations (Yola and Kaltungo) are presented in Table 3. At Yola, the variety that haboured the highest population was SAMSORG-17 with 50.81 / 10 panicles, followed by Ex-Tula Farafara cultivar (46.19 / 10 panicles), SAMSORG-14 (44.56 / 10 panicles) and least was on Tiksha-Mamza (Ex-Garkida) (12.78 / 10 panicles). At Kaltungo, it was SAMSORG-14 had the highest population of 69.53 / 10 panicles followed by SAMSORG-37 (52.19 / 10 panicles), and the least was on Ex-Tula Farafara cultivar (15.19 / 10 panicles). In the combined analysis, SAMSORG-14 was leading in the population of insect pests with (57.04 / 10 panicles) followed by SAMSORG-17 (44.10 / 10 panicles) and the least occurred in Tiksha-Mamza (Ex-Garkida) with a population of insect pests 19.11 /10 panicles (Table 3).

Species complex and abundance of insect pests at Yola and Kaltungo in 2012 cropping season are presented in Table 4. At Yola, *Monolepta* sp. was the highest insect species that occurred (2.60) followed by *E. oldi* (2.38) and the least was *M. religiosa.* At Kaltungo, *Eurystylus oldi* was the highest insect species followed by *Monolepta* sp. (1.28) with the least in *Pachnoda chordata* (0.72) (Table 4).

The species complex and abundance of panicle insect pests on eight sorghum varieties per week in location 1 (Yola) and location 2 (Kaltungo) in 2012 cropping season and the combined analysis is presented in figures 2, 3 respectively. In figure 2, the peak population of *E. oldi* occurred on 12 October with a mean population of 4.24. Population of *Monolepta* sp. was high on 19 October with a mean population of 4.24. The lowest population of insect species occurred at the last stage of sorghum development, from 23 to 30 November and it was the hard dough stage of the sorghum development.

UNDER PEER REVIEW

In figure 3, the peak population of *E. oldi* occurred on 31 October with a mean population of 4.93 and *S. zeamais* occurred on 17 October with a mean population of 6.57. These insect pests were found to be higher in 17 October and 31 October (milk stage and soft dough stage). 21 November and 28 November supported the lowest insect population in the sorghum (hard dough stage). In figure 3, which is the combined analysis the insect pests that was higher in all the weeks was *E. oldi, Orius* sp. and *Monolepta* sp. The lowest insect population of were *M. religiosa* and *P. chordata.*

Table 1: Sorghum Panicle Insects Species Complex Identified.

Species	Order	Family	Stage	Insect Status	Plate Number
Monolepta sp.	Coleoptera	Chrysomelidae	Adult	Pest	1
Spilostethus sp.	Heteroptera	Lygacidae	Adult	Pest	2
Eurystylus oldi	Hemiptera	Miridae	Adult	Pest	3
Nola sorghiella	Lepidoptera	Nolidae	Larva, Pupa & Adult	Pest	4
Agnoscelis versicola	Hemiptera	Pentatomidae	Adult	Pest	5
Campylomma sp.	Hemiptera	Aleyyrodidae	Adult	Pest	6
Erythroneura variabilis	Homoptera	Cicadellidae	Adult	Pest	7
Mirperus jaculatus	Hemiptera	Alydidae	Adult	Pest	8
Messor sp.	Aculeata	Formicidae	Adult	Pest	9
Pachnoda chordata	Coleoptera	Scarabaeidae	Adult	Pest	10
Sitophilus zeamais	Coleoptera	Curculionidae	Adult	Pest	11
Poophilus costalis	Hemiptera	Aprophoidae	Adult	Pest	12
Kraussaria angulifera	Orthoptera	Acrididae	Adult	Pest	13
Nezara viridula	Heteroptera	Pentatomidae	Adult	Pest	14
Silidius apicalis	Coleoptera	Chanthoridae	Adult	Pest	15
Achaearanea tepidariorum	Polyphaga	Aranae	Adult	Predator	16
Orius sp.	Hemiptera	Anthocoridae	Adult	Predator	17
Forficula senegalensis	Dermaptera	Forficulidae	Adult	Predator	18
Mantids religiosa	Dictyoptera	Mantoidae	Adult	Predator	19
Apis melifera	Hymenoptera	Apidae	Adult	Pollinator	20
Apocrita polistes	Aculeata	Apidae	Adult	Pollinator/ Pest	21

UNDER PEER REVIEW

Plate 1: *Monolepta* sp. (Adults) Panicle Head beetles

Plate 2: *Spilostethus* sp. (Adults)Panicle Sap sucking bug

Plate 3: *Eurystylus oldi* (Adults) – Panicle sap head bug

(a) (b) (c)

Plate 4: *Nola sorghiella* Panicle headworm (a) Larva (b) Pupa (c) Adult

Plate 5: *Agnoscelis versicola* (Adults) – Panicle Stink bug

Plate 6: *Campyloma* sp. (Adult) – Panicle Headbug

Plate 7: *Erythroneura variabilis* (Adult) – Leafhoppers

Plate 8: *Mirperus jaculatus* (Adults) – Grain/panicle sucking bug

UNDER PEER REVIEW

Plate 9: *Messor* sp. (Adult) – Harvester ants

Plate 11: *Sitophilus zeamais* (Adults) – Maize/Sorghum grain weevil

Plate 13: *Kraussaria angulifera* (Adults) – Grasshoppers

Plate 15: *Silidius apicalis* (Adults) – beetle

Plate 10: *Pachnoda chordata* (Adult) – panicle sucking bug

Plate 12: *Poophilus costalis* (Adults) – Spittle bug

Plate 14: *Nezara viridula* (Adults) – Green stink bug

Plate 16: *Achaearanea tepidoriorum* (Adults) Spider

UNDER PEER REVIEW

Plate 17: *Orius* sp. (Adults) Predator

Plate 18: *Forficula senegalensis* (Adults) Earwig

Plate 19: *Mantids religiosa* (Adult) – Mantis

Plate 20: *Apis mellifera* (Adults) Bees

Plate 21: *Apocrita polistes* (Adult) – Wasp

UNDER PEER REVIEW

Table 2: Mean weekly population of panicle insect pests of sorghum 2012 cropping season in two locations.

Time of the Year	Yola	Kaltungo	Combined analysis
12 and 14 Sept.	10.33[de]	3.54[d]	6.94[f]
19 and 21 Sept.	22.54[cd]	18.38[c]	20.46[e]
26 and 28 Sept.	31.38[c]	26.67[c]	29.02[de]
3 and 5 Oct.	20.83[cd]	57.25[b]	39.04[c]
10 and 12 Oct.	45.83[ab]	52.04[b]	48.94[b]
17 and 19 Oct.	47.75[ab]	100.38[a]	74.06[a]
24 and 26 Oct.	60.50[a]	30.17[c]	45.33[bc]
31 Oct. and 2 Nov.	50.83[ab]	96.46[a]	73.65[a]
7 and 9 Nov.	49.29[ab]	24.54[c]	36.92[cd]
14 and 16 Nov.	35.13[bc]	4.29[d]	19.71[e]
21 and 23 Nov.	1.88[e]	1.46[d]	1.67[f]
28 and 30 Nov.	0.75[e]	1.54[d]	1.45[f]
Mean	31.42	34.73	33.07
CV (%)	66.99	33.38	59.82
SE	21.05	18.54	19.78

Means with the same letter(s) are not significantly different at p=0.05 using Student-Newman-Keuls (SNK) test for variables

UNDER PEER REVIEW

Table 3: Mean cumulative insect pests on eight sorghum varieties in 2012 cropping season in two locations

Varieties	Yola	Kaltungo	Combined analysis
SAMSORG-41	21.94[bc]	25.58[de]	23.76[cd]
SAMSORG-14	44.56[a]	69.53[a]	57.04[a]
SAMSORG-17	50.81[a]	37.39[c]	44.10[b]
SAMSORG-37	27.97[b]	52.19[b]	40.08[b]
SAMSORG-39	18.75[bc]	32.53[cd]	25.64[cd]
Tiksha-Mamza (Ex-Garkida	12.78[c]	25.44[de]	19.11[d]
Ex-Tula Red Cultivar	28.36[b]	19.94[e]	24.15[cd]
Ex-Tula Farafara Cultivar	46.19[a]	15.19[e]	30.69[c]
Mean	31.42	34.73	33.07
CV(%)	66.99	53.38	59.82
SE	21.05	18.54	19.78

Means with the same letter are not significantly different at p=0.05 using Student-Newman-Kuels (SNK) test for variables

UNDER PEER REVIEW

Table 4: Species complex and abundance of insect pests on eight sorghum varieties on 10 panicles per plot of two locations in 2012 cropping season

Species	Yola	Kaltungo	Mean	CV (%)	SE
Monolepta sp.	2.60[a]	1.28[ab]	1.94	39.44	0.77
Apis mellifera	1.33[ab]	0.86[b]	1.09	47.07	0.51
Achaearanea tepidariorum	1.06[ab]	1.07[b]	1.07	26.30	0.28
Spilostethus sp.	0.86[b]	1.22[ab]	1.04	36.06	0.78
Orius sp.	0.74[b]	0.85[b]	0.80	22.78	0.18
Forficula senegalensis	0.85[b]	0.74[b]	0.80	22.78	0.18
Eurystylus oldi	2.38[a]	2.17[a]	2.28	42.31	0.81
Nola sorghiella	0.84[b]	0.80[b]	0.82	22.67	0.19
Oebalus gugnax	0.78[b]	0.95[b]	0.86	26.30	0.23
Campylomma sp.	0.78[b]	0.75[b]	0.77	28.46	0.22
Erythroneura variabilis	0.75[b]	0.73[b]	0.74	15.69	0.12
Mirperus jaculatus	0.74[b]	0.79[b]	0.76	17.98	0.14
Messor sp.	0.73[b]	0.83[b]	0.78	16.62	0.13
Mantids religiosa	0.71[b]	0.74[b]	0.72	13.17	0.10
Pachnoda chordate	0.73[b]	0.72[b]	0.72	11.45	0.08

Means with the same letter are not significantly different at p=0.05 using Student-Newman-Kuels (SNK) test for variables

UNDER PEER REVIEW

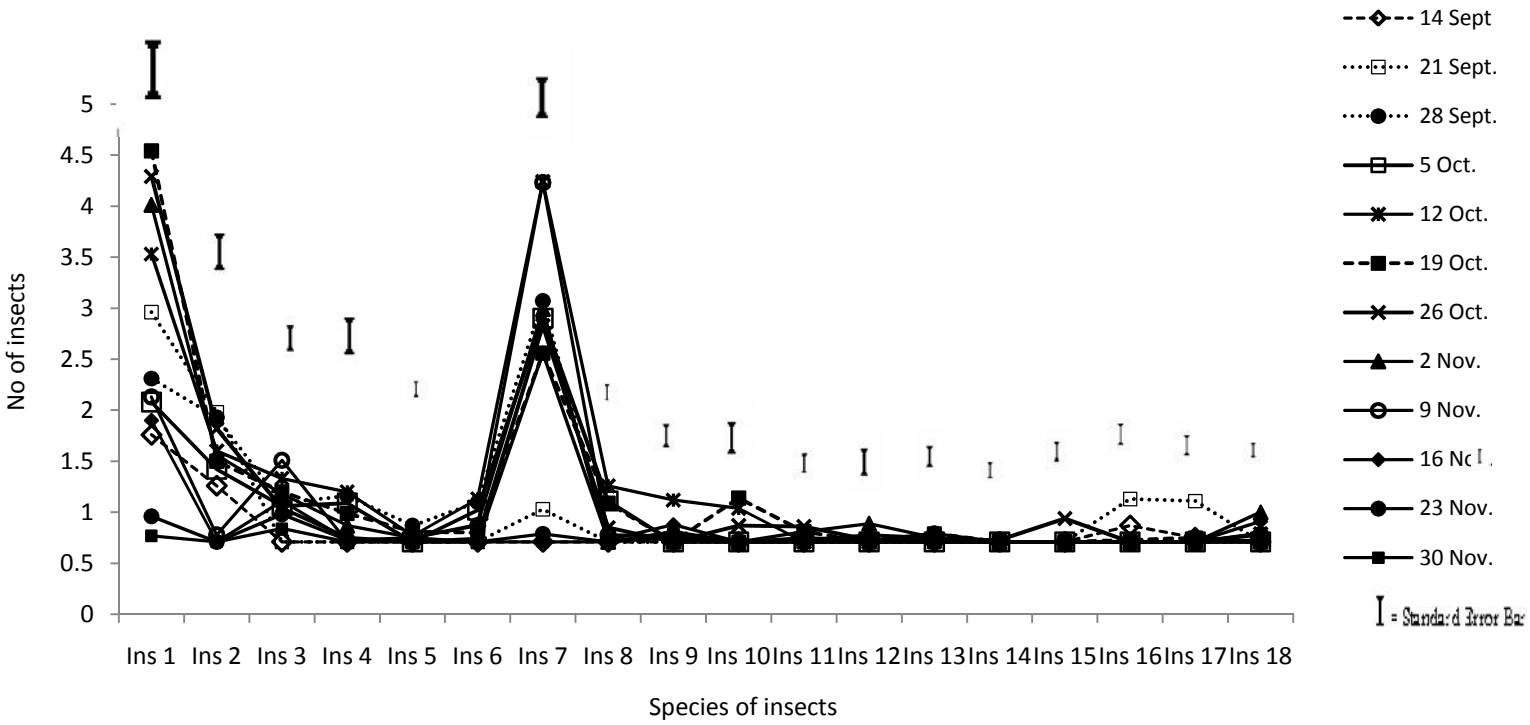

Figure 1: Species complex and abundance of insect pests per week on sorghum in 2012 cropping season at Yola

Key:

Ins 1 = *Monolepta* sp.
Ins 2 = *Apis mellifera*
Ins 3 = *Achaearanea tepidariorum*
Ins 4 = *Spilostethus* sp.
Ins 5 = *Orius* sp.
Ins 6 = *Forficula senegalensis*
Ins 7 = *Eurystylus oldi*
Ins 8 = *Nola sorghiella*
Ins 9 = *Agnoscelis versicola*
Ins 10 = *Campylomma* sp.
Ins 11= *Erythroneura variabilis*
Ins 12 = *Mirperus jaculatus*
Ins 13 = *Messor* sp.
Ins 14 = *Mantids religiosa*
Ins 15 = *Pachnoda chordata*.
Ins 16 = *Silidius apicalis*
Ins 17 = *Apocrita polistes*
Ins 18 = *Nezara viridula*

UNDER PEER REVIEW

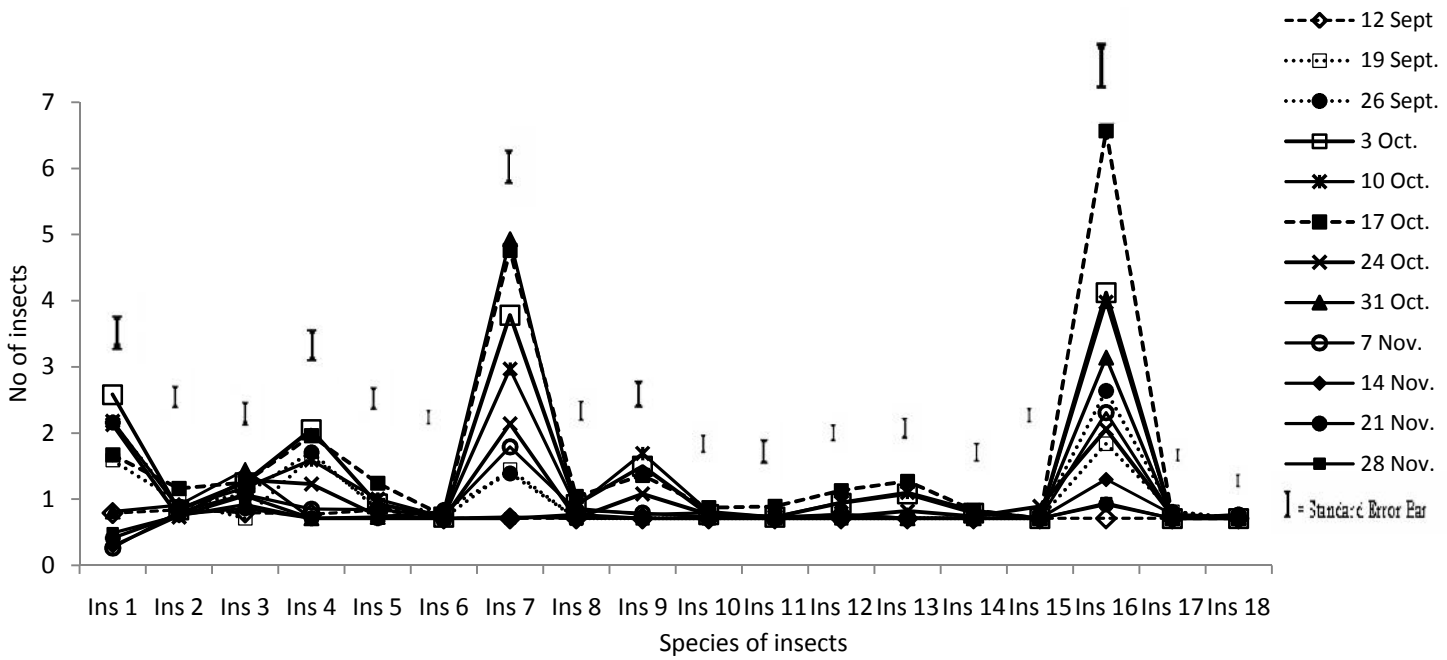

Figure 2: Species complex and abundance of insect pests per week on sorghum in 2012 cropping season at Kaltungo

Key:

Ins 1 = *Monolepta* sp.
Ins 2 = *Apis mellifera*
Ins 3 = *Achaearanea tepidariorum*
Ins 4 = *Spilostethus* sp.
Ins 5 = *Orius* sp.
Ins 6 = *Forficula senegalensis*
Ins 7 = *Eurystylus oldi*
Ins 8 = *Nola sorghiella*
Ins 9 = *Agnoscelis versicola*
Ins 10 = *Campylomma* sp.
Ins 11= *Erythroneura variabilis*
Ins 12 = *Mirperus jaculatus*
Ins 13 = *Messor* sp.
Ins 14 = *Mantids religiosa*
Ins 15 = *Pachnoda chordata*
Ins 16 = *Sitophilus zeamais*
Ins 17 = *Poophilus costalis*
Ins 18 = *Kraussaria angulifera*

UNDER PEER REVIEW

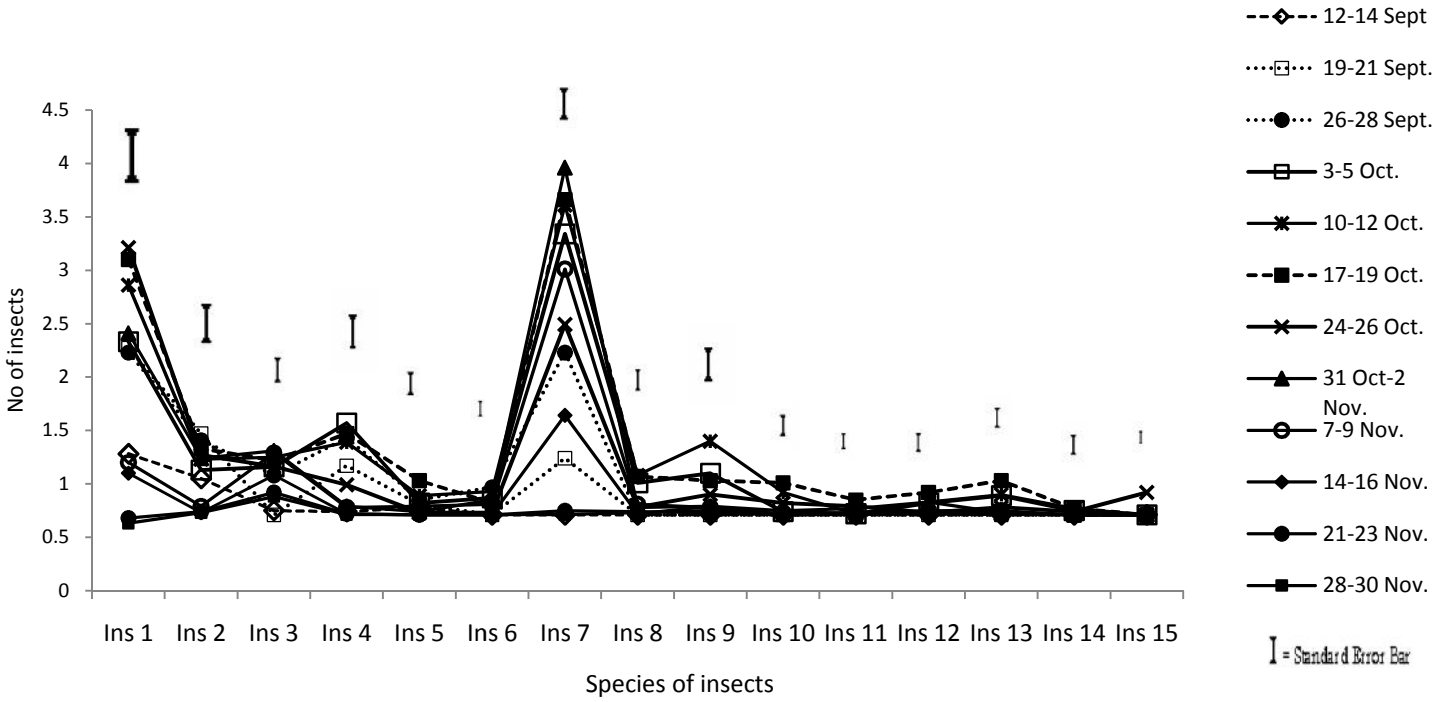

Figure 3: Species complex and abundance of insect pests per week on sorghum in 2012 cropping season in combined analysis

Key:

Ins 1 = *Monolepta* sp.
Ins 2 = *Apis mellifera*
Ins 3 = *Achaearanea tepidariorum*
Ins 4 = *Spilostethus* sp.
Ins 5 = *Orius* sp.
Ins 6 = *Forficula senegalensis*
Ins 7 = *Eurystylus oldi*
Ins 8 = *Nola sorghiella*
Ins 9 = *Agnoscelis versicola*
Ins 10 = *Campylomma* sp.
Ins 11= *Erythroneura variabilis*
Ins 12 = *Mirperus jaculatus*
Ins 13 = *Messor* sp.
Ins 14 = *Mantids religiosa*
Ins 15 = *Pachnoda chordata*

DISCUSSION

The different species of panicle insects identified at Yola and Kaltungo showed that 21 species of panicle insects were identified in both locations. Honey bee, *Apis mellifera* and Wasp, *Apocrita polistes,* are well-known pollinators and they occurred during the anthesis stage of sorghum development, these are not pests except they sting human beings working on the farm. This is in conformity with (24). *Orius* sp. and preying mantis, *Mantids religiosa,* occurred in abundance at complete anthesis and milk stages of sorghum development, while earwigs, *Forficula senegalensis* occurred at soft dough stage of sorghum development in low population and spiders, *Achaearanea tepidariorum* occurred at all stages of sorghum development, these are not pests but predators mostly on headbugs, wherever their population increases the number of insect pests decreases, and this findings also agrees with (25,8,26,2,12), whom in their work observed that they are predators on panicle insect pests especially on headbugs. The chrysomelid beetle,

UNDER PEER REVIEW

Monolepta sp. occurred in abundance at Yola and mostly on Ex-Tula Farafara cultivar, sap sucking bug, *Spilostethus* sp.; headbug, *Eurystylus oldi* the insect pest that has the highest population count and SAMSORG-14 haboured these pests in high populations both at Yola and Kaltungo. This corroborates the findings of (2) and (1). The webworm, *Nola sorghiella* were found on sorghum panicles which formed webs on developing grains that further contaminates the quality of the grains. The stink bug, *Agnoscelis versicola*; head bug, *Campylomma* sp.; hoppers, *Erythroneura variabilis*; pod sucking bug *Mirperus jaculus*; harvester ant, *Messor* sp.; pod sucking bug, *Pachnoda. chordata* and maize weevil, *Sitophilus zeamais.* The *S. zeamais* occurred in abundance only in Kaltungo, also spittle bug, *Poophilus costalis* and grasshopper, *Kraussaria angulifera*. The green stink bug, *Nezara viridula*, and *Silidius apicalis* were only found in Yola. *N. viridula* occurred only on SAMSORG-17. The differences in Yola and Kaltungo could be due to the differences in geographical zones regarding rainfall and probably temperature. Such differences also validate the findings of (27,2,28), who found that geographical locations could affect on influence insect abundance or population negatively or positively depending on the habitat, rainfall patterns, temperature and relative humidity at a point in time when data was collected.

The results showed that, all the SAMSORG varieties, habours more panicle insects, compared to the local cultivars of Ex-Garkida and Ex-Tula. These showed that, they are promising cultivars which could be resistant to panicle insect pests. Tiksha-Manza despite that it a semi-compact panicle, the red pigmentation which is high in tannin content might have been the reason that it was not favourable to panicle insect pests of sorghum, particularly *E. oldi*, which supported the earlier findings of (2,29) that red pigmented sorghum that are usually high in tanin content is unfavourble to panicle insect pests. The Ex-Tula(s) are tall, with loose-panicles which usually matures late were not favourable for nesting of insects due to its pendulus panicles which matures late in the season are affected by it's by the onset of harmattern brought by the strong North East wind that makes it almost impossible for the insects (2).

In conclusion, the results on the species complex and abundance of sorghum panicle insect pests is an important step in knowing the complexity and abundance of a whole insect spectrum on sorghum at different times of the year, which time in the season or year they appear mostly and at what growth stage of sorghum they appear and which of the sorghum varieties habours the highest panicle insect pests population. It is also a step that reveals planting dates of could be manipulated to escape high incidence and damage due to insect pests of sorghum as earlier stated by (30).

UNDER PEER REVIEW

REFERENCES

ICRISAT(International Crop Research Institute for Semi-Arid Tropics) (1991). Sahelian Centre (ICRISAT) *West Africa Programme Annual Report 1990*. Bp 12404 Niamey, ICRISAT Sahelian Centre.

Malgwi, A.M. (1997). Studies of Sorghum, *(Sorghum bicolor* L. Moench) head bugs. Samaru, Zaria. MSc. (Crop Protection) Thesis, Ahmadu Bello University Zaria.

Bello, D. (2010). *Combining Ability and Heteroses for Agronomic characters and malting Quality Traits of Grain Sorghum in Adamawa State* a Ph.D Thesis submitted to Department of Crop production and Horticulture. Federal University of Technology Yola Pp 1 – 4.

Singh, S.P., Jotwani, M.G., Rano, B.S. and Rao, N.G.P. (2003). Stability of host plant resistance to sorghum shootfly, *Atherigora soccata* (Rondan). *India Journal of Entomology* 40: 376-383.

Taylor, J.R.N. (2003). Overview: *Importance of Sorghum in Africa.* In: Belton, P.S. & Taylor, J.R.N. (Editors). Proceedings of the workshop on the proteins of sorghum and millet: enhancing nutritional and functional properties for Africa, Pretoria, South Africa, 2-4 April 2003. Afripro (internet) http://www.afripro.org.uk/. Accessed 2011/01/18.

Leuschner, K. (1985). *Sorghum Entomology Research Programme and Need in Developing World* 1985.

Nwanze, K.F. (1985). *Sorghum Pests of West Africa* in: proceeding of International Sorghum Entomology Workshop 15-21 July, 1985. College Station Texas, USA Pantecheru, pp 502324 India ICRISAT pp. 37-43.

McFarlane, J.H. (1989). The hemipterous insects and spiders of sorghum in Northern Nigeria. *Insect Science and its Application,* 10: 277-284.

Seshu Reddy, KV (1991). Insect Pests of Sorghum in Africa. *Insect Science and its applications,* 12 (516): 653-657.

Malgwi, A.M. (1999). The damage potentials of the most prominent headbug, *Eurystylus oldi*, Poppius as a head bug in Nigeria, in: *Nigerian Journal of tropical Agriculture,* Vol. 1. 1999 (21-25).

Tanzubil, P.B., Alen, A. and Zakaria, M. (2007). Insect infestant les panicules de sorgho (*Sorghum bicolor* (L.) Moench) dans le nord du Ghana 1.La. *Ghana Journal of Agricultural Science*, 40: 43-5044

Malgwi, A.M. and Ajayi, O. (2011). Population dynamics of *Eurystylus oldi* Poppius (Heteroptera: Miridae) at different stages of sorghum development at Samaru, Nigeria. *Journal of Arid Agriculture* Vol. 2011: 97-103.

Bowden, J. (1965). Sorghum midge, *Contarinia sorghicola* and other causes of grain sorghum losses in Ghana. *Bull. Ent. Res* 56, 169 – 189.

Agyen-Sampong, M. (1978). Insect pests of sorghum head and assessment of crop loss by the major pests. *Ghana Journal of Agric. Sci.* 11, 109 – 115.

UNDER PEER REVIEW

Tanzubil, P.B (1997). Non-pesticidal approaches to managing insect pests of sorghum in Ghana. In *Improvement of cropping systems in the savanna zone: The challenges ahead. Proceedings of the 3rd National workshop on improving farming systems in the interior Savanna of Ghana* (ed. H. Mercer-Quarshie, K. O. Marfo, S.A.Langyintou & R. Owusu), pp 227 – 236. Nyankpala, April 1996.

Tanzubil, P. B. Zakaria, M. and Alem, A. (2005). Population ecology and damage potential of Mirid bugs infesting sorghum panicles in Northern Ghana. *Tropical Science.* 45, 58 – 62.

UBRBDA (Upper Benue River Basin Development Authority). (1999). 1998 *Annual Report* Upper Benue River Basin development Authority Yola – Nigeria pp 31-32.

Wikipedia (2011). *Kaltungo.* En.wikipedia.org/wiki/kaltungo. Accessed 2012/03/23.

Dunuwel, D. M. (2012). Species Complex, Abundance, Damage and Control of Panicle Insect Pests of Sorghum (*Sorghum bicolor* L. Moench) at Gombe and Yola in North Eastern Nigeria. M.Sc Thesis 90pp (unpublished) submitted to the Department of Crop Protection, Modibbo Adama University of Tech., Yola.

Malgwi, A.M. and Dunuwel, D. M. (2013a).Damage and Control of Panicle Insect Pests of Sorghum (Sorghum bicolor (L.) Moench) in North eastern Nigeria. *ARPN Journal of Science and Technology*, Vol. 3, No. 2: 195-202pp. February 2013. Walnut Street, USA KAGI Academic Publishers 9pp. ISSN 2225-7217 . ©2011-2013.

Steck, G.J., Teetes, G.L. and Maiga, S.D. (1989). Species composition and injury to sorghum by panicle feeding bugs in Niger *Insect Science and its Application* 10:199-217.

Sharma, H.C., Taneja, S.L., Leuschner, K. and Nwanze, K.F. (1992). Techniques to screen sorghum for resistance to insect pest ICRISAT *Information Bulletin,* No. 32:4pp.

SAS (Statistical Analysis Systems) (2000). SAS/STAT User's Guide, Version 8 (2). Statistical Analysis Systems. Institute Inc., Cary, North Carolina, USA.

Dennis, S.H. (1983). *Agricultural insect pests of the tropics and their control.* 2nd Edn Cambridge, U.K.,Cambridge University press pp 174.

Descamps, M. (1954). Insectes nuisible aux cultures et. Insects pre'dateurs re'cement observe's dans le Nord Cameroon. *Agronomie Tropicale* 9: 174-182.

Ratnadas, A. and Ajayi, O., (1995). *Panicle insect pests of Sorghum in West Africa* pages 29-38 in. panicle Insect pests of Sorghum and pearl millet:Proceedings of an international consultative workshop 4-7 0ct. 1993. ICRISAT Sahelian center Niamey,Niger (Nwanze,K.F and Youm, O. eds) Patacheru 502 324, A.P. India. ICRISAT.

Doumbia Y. O and Teetes, G.L. (1991). Distribution, degats et dynamique des population d' *Eurystylus marginatus* (Odh) [Heteroptera: Miridae], ravageur du sorgho au Mali. Conference Inter-rescaux sur la recherché et. la production des cultures vivrieres en Afrique semi-aride. Niamey 7 – 15 Mars 1991, Niger.

Doumbia, Y.O. (2001). Incidence and distribution of sorghum headbug *Eurystylus oldi* (Hemiptera: Miridae) in West and Central Africa. *Insect Science and its Application,* 21: 103-117.

UNDER PEER REVIEW

Yadumma, J.J. (2000). The effect of Tamarind ash and Permaguard on S*itophilus zeamais* (Motch.) Coleoptera:Curculionidae) on stored maize and sorghum. Unpublished undergraduate project.

Malgwi, A.M., Ajayi, O., Ogunlana, M.O. and Onu, I (2000). Evaluation of headbugs Population and Damage on Sorghum, at different sowing dates at Samaru, Zaria. *Entomological Society of Nigeria (ESN) Occasional Publication* 32: 107 – 112 (2000).ISBN 978-33086-2-9.