ZIBELINE INTERNATIONAL™ PUBLISHING

SSN: 2521-0858 (Print)
ISSN: 2521-0866 (Online)
CODEN: SHJCAS

Science Heritage Journal (GWS)

DOI: http://doi.org/10.26480/gws.01.2022.01.05

RESEARCH ARTICLE

MORPHOMETRIC IDENTIFICATION OF MAIZE WEEVILS (*Sitophilus* spp.) IN FCT-ABUJA, NIGERIA

Oyewale, R.O.*, Abolarinwa, O., Bolajoko, M.H., Isah, C., Mamudu, A.Y., Ibrahim, H.M.

Department of Crop Production, Federal University of Technology, Minna, Niger State, Nigeria.
Corresponding Author E mail: r.oyewale@futminna.edu.ng

ARTICLE DETAILS

Article History:

Received 27 November 2021
Accepted 30 December 2021
Available online 05 January 2022

ABSTRACT

Five Area Councils were selected for the study from the six Area Councils of Federal Capital Territory (FCT-ABUJA) namely; Gwagwalada, Kuje, Kwali, Abaji and AMAC. Three markets were surveyed in each of the Area Council to obtain one measure of infested maize with maize weevils (*Sitophilus* species) and ten of the insects were selected randomly from each measure and kept separately in a covered jar containing ethanol solution. The sample were taken to Insect Laboratory (Insect Museum), at the Department of Crop Protection, Faculty of Agriculture, Ahmadu Bello University, Zaria, Kaduna State for identification. MI scope was used to carry out the morphometric measurement. The features of the insect measured include the wholebody length, Body width, Hind limb, Fore limb, Head, Antennae, Tarsi, Width of Femur, Femur. Then Microscope was use to view and compare the collected insects with other genus of *Sitophilus* in the insect collection boxes in the museum. The features measured were converted from pixel per length (p/l) to millimeter and subjected to Analysis of Variance (ANOVA) using statistical package version 9.0. The means were separated using Duncan Multiple Range Test (DMRT) at 5 % level of probability. Results obtained indicated that Kuje and Abaji Area Councils had varied diversity of features of *Sitophilus granarius* and only *Sitophilus granarius* was identified in all the five Area Councils of FCT-Abuja, Nigeria.

KEYWORDS

Area council, *Sitophilus granarius,* measure, features, insects

1. INTRODUCTION

Maize (*Zea mays* L.) is an essential component of global food security. It serves as a valuable cereal crop in the world due to its diverse uses as food, feed and raw materials for man, livestock and several industries respectively (Gupta et al., 2015). In the world, it is one of the most grown crops and a major staple crop for many small holder farmers. It is one of the cereal crops grown in various agro-ecological zones, as both single crop and/ or in mixed cropping. It has highest production potential and the third most important cereal in the world, next to rice and wheat (Prathyusha et al., 2013). It is one of the main cereals crops of West Africa and the most important cereal food in Nigeria (Onuk et al., 2010). Maize, compared to other cereals, is high yielding, easy to process, readily digested, and cheaper. According to IITA, maize is a versatile crop and every part of the maize plant has economic value: the grain, leaves, tassel, and cob can all be used to produce a large variety of food and non-food products (IITA, 2009).

More than 883 mega grams of corn were produced worldwide in 2011 (FAOSTAT, 2013). Maize is widely cultivated throughout the world, and there is an increase weight of maize produced each year than any other grain. Many developing countries are actively growing corn as the demand for corn grows at approximately 2.2 % per year, (Fran, 2012). Different types of maize are grown worldwide including Flint, dent, floury, waxy, pop and sweet corn. Maize can strive in different climatic conditions and is grown by Small holder familes in many countries such as the United States, Argentina, Brazil, Canada, China, European Union, India, Mexico, Ukraine and South Africa (USDA, 2013). Maize is one of the most crucial and strategic cereal crops in Africa and developing world in general. It is produced in different parts of the continent under diverse climate and ecological conditions. Maize is the preferred staple for about 900 million poor consumers and about one third of all malnourished children in Africa (FARA, 2009).

It is one of the most important commodities used for food aid to the deadly war and hunger areas of the world. Since maize is cheaper than other cereals such as rice, and wheat, it is more affordable to the vast majority of the population, and therefore occupies a prominent position in the agricultural development agenda of several countries in Africa (FARA, 2009). Maize is attacked by various field and storage pests in spite of the above mentioned uses such as: Maize weevil, *Sitophilus* spp Motschulsky (Coleoptera: Curculionidae). It is a major pest of different species that attack stored maize grains in the tropics and temperate regions of the world (Sagheer et al., 2013). Subsequent infestations in store result from transfer of infested grain into store or from the pest flying into storage facilities, probably attracted by the odour of the stored maize. Weight losses of as much as 30 - 40% may cause by heavy infestation of this pest (Radha, 2014). The estimated global annual losses due to pests activities

Quick Response Code	Access this article online	
	Website: www.jscienceheritage.com	**DOI:** 10.26480/gws.01.2022.01.05

Cite The Article: Oyewale, R.O., Abolarinwa, O., Bolajoko, M.H., Isah, C., Mamudu, A.Y., Ibrahim, H.M. (2022). Morphometric Identification of Maize Weevils (*Sitophilus* Spp.) In Fct-Abuja, Nigeria. *Science Heritage Journal, 6(1): 01-05.*

in the field and storage are valued more than one hundred billion dollar (Yohannes et al., 2014).

The most obvious signs of infestation is the emergence of adults since early detection of infestation is difficult as *Sitophilus* spp larvae feed on the interior of individual maize grains leaving behind only the hills, a flour-like grain dust, mixed with frass (Cabi, 2015). Rationally it makes more sense and economical to safeguard the crop that has been harvested instead of trying to make up for the losses through development in production. There is evidence of seed and food insecurity arising from high storage losses, inspite of the efforts made in increasing production and productivity of maize through the development of high yielding stress tolerant varieties in the country. In Africa, the storage of grains for used as food and seed for future sowing is commonly practiced by small holder farmers. However, the major drawback during long-term storage is the preservation of the quality of the grain (Tefera et al., 2011).

One of the factors responsible for the high storage losses is the problem of stored grain insect pests, such as: maize weevil, *Sitophilus granarius, Sitophilus zeamais* (Motschulsky); rice weevil, *S. oryzae* (L.); Angoumois grain moth, *Sitotrogam cerealella (*Olivier); and the larger grain borer, *Prostephanus truncatus* (Horn) (Hodges, 2012). High storage losses experienced by small holder farmers threaten their livelihoods in Africa (Kamanula et al., 2011). *Sitophilus granarius* belongs to the order Coleoptera and family Dryophthoridae. The biology and behaviour of *S. granarius* is similar to the tropical species, *S. oryzae* and *S. zeamais* except that it cannot fly. Adult *granarius* weevils can vary considerably in size between 2.5-5.0 mm in length, although 3 to 4 mm is usual. They have the characteristic rostrum (snout or beak) and elbowed antennae of the family Curculionidae (weevils). They are shiny and reddish-brown to black in colour and pitted with numerous punctures.

They have an irregular pattern of the punctures on the thorax while those on the elytra (wing cases) are in lines. The antennae have eight segments and are often carried in an extended position when the insect is walking. The body has a sparse covering of short, yellow hairs. The larvae of maize weevils are white, fleshy and legless. Female usually lay around 150 to 300 eggs throughout their lives and one egg is deposited in each grain kernel. Both larval and the pupal stages occur within the grain. Larvae are rarely seen outside the grain kernels because they feed inside the grain until pupation, after which they bore a hole out of the grain and emerge as adults which can live up to 8 months after emerging. Eggs are laid individually in cavities that the female drills in the grain kernels. Cavities are sealed by a waxy plug, which the female secretes. Depending on temperature and humidity, eggs incubate for about 4-14 days before hatching.

One larva develops in each infested kernel. Feeding larvae excavate a tunnel and may keep feeding until only the hull remains. There are four larval instars all of which occur in the grain. Pupation also occurs inside the grain. The newly emerged adult chews its way out of the grain, leaving a characteristic large and roughly rectangular exit hole with ragged edges. Having left the kernel the female releases a sex pheromone to attract males for mating. In warm conditions the life cycle can be completed within 4-6 weeks, but this can be up to 21 weeks in the winter. Adults can survive for a month or more without food in cooler conditions. Optimum conditions for development are similar to other tropical species of *Sitophilus*, about 30°C and 70% RH, but in tropical areas it is apparently not able to compete with *S. oryzae* and S. *zeamais* (Richards, 1947). It seems that its distribution is limited more by its commodity associations with cool climate crops than by its direct response to temperature.

However, it can develop at temperatures down to 11°C and is therefore successful in temperate regions that are too cool for other *Sitophilus* species (Howe, 1968). Being flightless, *S. granarius* cannot usually infest crops in the field before harvest but can walk fairly long distances and can be dispersed further in infested grain. It is capable of penetrating and infesting intact kernels of grain in which immature stages develop leaving the maize emptied of its nutritional and seed values, culminating in outright loss of visual appeal at the local and the international market (Lale and Ofuya, 2001). These pests are carried all over the world in grain shipments and can establish themselves wherever there is food and where grain moisture and temperature are favourable. It is one of the most common insect pests of stored maize in most African countries and occurs in all sub-regions. Therefore, the present work tend to identify if there was any different species of *Sitophilus* in the selected Area Councils of FCT-Abuja. The results obtained will be recommended to the farmers and stakeholders for proper management strategies. The objectves of this research therefore was to study the morphometric features of maize weevils and be used to classify them into different species in selected Area CouncilS of Federal Capital Territory (FCT-Abuja).

2. Materials and Methods

2.1 Description of the Study Area

Five Area Councils were selected for the study from the six Area Councils of Federal Capital Territory (FCT-ABUJA) namely, Gwagwalada, Kuje, Kwali, Abaji and AMAC. Three markets were surveyed in each of the Area Council to obtain one measure of infested maize with maize weevils (*Sitophilus* spp) and ten of the insects were selected randomly from each measure and kept separately in a covered jar containing ethanol solution.

2.2 Identification Techniques

Ten maize weevils each from the three locations of each Area CouncilS were kept in different transparent containers and labeled in order to be specific on the various areas in which they were collected. The sample were taken to insect laboratory (insect museum), at the Department of Crop Protection, Faculty of Agriculture, Ahmadu Bello University, Zaria, Kaduna State for identification. MI scope was used to carry out the morphometric measurement. The features of the insect measured include the wholebody length, Body width, Hind limb, Fore limb, Head, Antennae, Tarsi, Width of Femur, Femur. Then Microscope was use to view and compare the collected insects with other genus of *Sitophilus* in the insect collection boxes in the museum.

2.3 Experimental Design

The experiments consisted of five Area Councils and 3 Markets from each Area Council

2.4 Data Analysis

The data collected were converted from pixel per length (p/l) to millimeter and subjected to Analysis of Variance (ANOVA) using statistical package version 9.0. The means were separated using Duncan Multiple Range Test (DMRT) at 5 % level of probablty.

3. Results

3.1 Morphometric diversity of *Sitophilus granarius* in the three market of Kuje Area Council of FCT-ABUJA.

The diversity result of the *Sitophilus granarius* in the surveyed markets of Kuje Area Council (Table 1) showed that the whole-body length, Body Width, Hindd Limb, Fore Limb, Head, Antennae and Tarsi have no significant difference. While the Width of Femur of the insect (S*itophilus granarius*) collected from kuje market showed a significant difference ($p \leq 0.05$) compare to Rubochi and Chukuku market.Also the Femur of the insect (*sitophilusgranarius*) collected at Rubochi market was significantly different($p \leq 0.05$) and longer than that of Kuje and Chukuku markets.

3.2 Morphometric diversity of *Sitophilus granarius* in the three market of GwagwaladaArea Council of FCT-ABUJA

The results revealed that there was no significant difference throughout the parameters collected on the insect pest (*Sitophilus granarius*) in the three market of Gwagwalada Area Council (Table 2).

3.3 Morphometric diversity of*Sitophilus granarius* in the three market of Abuja MunicipalArea Council of FCT-ABUJA

The whole-body length, Body Width, Fore Limb, Head, Antennae, Tarsi and Femurshowed no significant differencethroughout the parameters collected in the three markets of Abuja Municipal Area Council (Table 3). While the Hind limb showed a significantly difference (p≤0.05). The longest significant Hind limb(90.96mm) of the insect (*Sitophilusgranarius*)was collected at Gosamarket and the lowest (54.12mm) was recorded at Karimu Market.

3.4 Morphometric diversity of *Sitophilus granarius* in the three market of Abaji Area Council of FCT-ABUJA

The result showed in Table 4 showed that *S.granarius* in Yaba market has significant (p≤0.05) longest whole body length compared to Agyana market but not significantly different from Abaji market. Similarly, Antennae of the insect (*S.granarius*) collected from Agyana market was significsntly longer (p≤0.05) than those obtained in Yaba and Abaji market of the Abaji Area Council of FCT-ABUJA. Other features measured were not significantly different from one another.

3.5 Morphometric diversity of *Sitophilus granarius* in the three market of Kwali Area Council of FCT-ABUJA

The Antennae showed a significant different (p≤0.05) among the three markets as shown in Table 4.5, the longest significant antennae were recorded in Kaota market (24.96mm) compared toDafa and Kwali market.

While the Whole-Body Length, Body Width, Hind limb, Fore limb, Head, Tarsi, Width of femur and Femur showed no significant difference throughout in the three markets of Kwali Area Council of FCT-Abuja.

3.6 Morphometric diversity of *Sitophilusgranarius* in the Five Area Council of FCT-ABUJA

The result shown in Table 6 revealed that Kwali Area Council has shortest significant (p≤0.05) whole body length compared to Kuje, Gwagwalada and AMAC but not significantly different from Abaji Area Council. Also, Gwagwalada Area Council had the heaviest significant (p≤0.05) body width compared to Abaji but not significantly different from Kuje, AMAC and Kwali Area Councils. In the same vein, the longest significant (p≤0.05) Hind limb was obtained in AMAC compared to Kuje, Gwagwalada, Abaji and Kwali Area Council. No significant difference was recorded mong the Area Council for Fore limb, Tarsi, Width of femur and Femur among the Area Councils surveyed. On the other hand, Abaji Area Council recorded smallest significant(p≤0.05) difference head compared to Kuje and Gwagwalada Area Councils but not significantly different from AMAC and Kwali Area Councils. Similarly there was significant difference (p≤0.05) in Antennae of Sitophilus granarius of the Area Council of FCT-ABUJA with Gwagwalada having the longest significant (p≤0.05) Antennae compared to those obtained in Abaji and Kwali Area Council. Soalso Kwali recorded shortest significant (p≤0.05) Antennaecompared to AMAC, Gwagwalada and Kuje area council of FCT-ABUJA.

Table 1: Morphometric diversity of *Sitophilus granarius* in the three market of Kuje Area Council of FCT-ABUJA

KUJE AREA COUNCIL	WBL	BW	HL	FL	H	A	T	WF	F
Kujemarket	114.62^{ab}	35.68^{ab}	62.17^{b}	64.45^{a}	41.95^{a}	25.13^{a}	12.40^{a}	7.25^{a}	19.12^{a}
Rubochi market	109.20^{abcd}	35.59^{a}	55.17^{b}	57.51^{a}	38.48^{ab}	24.29^{a}	14.83^{a}	6.65^{a}	24.47^{b}
Chukuku market	109.27^{abcd}	35.60^{ab}	55.44^{b}	59.38^{a}	39.32^{ab}	25.07^{a}	13.53^{a}	7.18^{a}	24.39^{a}
SE±7.68	1.93	8.6	12.14	3.08	2.61	2.73	1.54	3.92	

Means with the same letter(s) in the same column are not significantly different by Duncan Multiple Range Test (DMRT) at 5% level of probability

KEY: WBL= Whole body length, BW= Body width, HL= Hind limb, FL= Fore limb, H= Head, A= Antennae, T=Tarsi, WF= Width of femur, F= Femur.

Table 2: Morphometric diversity of *Sitophilusgranarius* in the three market of Gwagwalada Area Council of FCT-ABUJA

KUJE AREA COUNCIL	WBL	BW	HL	FL	H	A	T	WF	F
Zuba market	103.81^{abcd}	36.73^{a}	61.53^{b}	62.31^{a}	40.20^{ab}	26.45^{a}	13.02^{a}	6.98^{b}	24.89^{a}
Dobi market	108.90^{abcd}	35.28^{ab}	57.38^{b}	55.39^{a}	39.65^{ab}	26.89^{a}	11.74^{a}	8.22^{b}	25.84^{a}
Gwag Market	116.10^{a}	35.79^{ab}	51.91^{b}	63.96^{a}	41.07^{ab}	26.69^{a}	14.05^{a}	7.52^{b}	20.31^{a}
SE±	7.68	1.9	8.6	12.14	3.08	2.61	2.73	1.54	3.92

Means with the same letter(s) in the same column are not significantly different by Duncan Multiple Range Test (DMRT) at 5% level of probability

KEY: WBL= Whole body length, BW= Body width, HL= Hind limb, FL= Fore limb, H= Head, A= Antennae, T=Tarsi, WF= Width of femur, F= Femur, Gwag= Gwagwalada.

Table 3: Morphometric diversity of *Sitophilusgranarius* in the three market of Abuja Municipal Area Council (AMAC) of FCT-ABUJA

AMAC COUNCIL	WBL	BW	HL	FL	H	A	T	WF	F
Gosamarket	108.55^{abcd}	35.07^{ab}	90.96^{a}	59.35^{a}	39.83^{ab}	24.95^{a}	12.60^{a}	7.28^{b}	23.46^{a}
Deideimarket	109.96^{abc}	34.58^{ab}	57.90^{b}	55.34^{a}	38.64^{ab}	25.31^{a}	12.25^{a}	6.87^{b}	25.92^{a}
karimu market	109.59^{abc}	34.30^{ab}	54.12^{b}	58.38^{a}	39.10^{ab}	25.43^{a}	11.27^{a}	6.71^{b}	24.79^{a}
SE±	7.68	1.93	8.6	12.13	3.08	2.61	2.73	1.54	3.92

Means with the same letter(s) in the same column are not significantly different by Duncan Multiple Range Test (DMRT) at 5% level of probability

KEY: WBL= Whole body length, BW= Body width, HL= Hind limb, FL= Fore limb, H= Head, A= Antennae, T=Tarsi, WF= Width of femur, F= Femur.

Table 4: Morphometric diversity of *Sitophilusgranarius* in the three market of Abaji Area Council of FCT-ABUJA

ABAJI AREA COUNCIL	WBL	BW	HL	FL	H	A	T	WF	F
Abaji market	3 4.16$^{a\,b}$	3 4.16$^{a\,b}$	55.75^{b}	47.10^{a}	37.71$^{a\,b}$	25.66^{a}	12.94^{a}	6.59^{b}	23.92^{a}
Agyana market	100.69^{bcd}	32.31^{b}	53.67^{b}	55.40^{a}	35.80^{ab}	18.82^{b}	12.92^{a}	6.61^{b}	22.97^{a}
Yaba market	117.10^{a}	34.69^{ab}	59.47^{b}	60.96^{a}	36.21^{ab}	24.26^{a}	14.29^{a}	7.35^{b}	26.10^{a}
SE±	7.68	1.93	8.6	12.14	3.08	2.61	2.73	1.543.92	

Means with the same letter(s) in the same column are not significantly different by Duncan Multiple Range Test (DMRT) at 5% level of probability

KEY: WBL= Whole body length, BW= Body width, HL= Hind limb, FL= Fore limb, H= Head, A= Antennae, T=Tarsi, WF= Width of femur, F= Femur.

Table 5: Morphometric diversity of *Sitophilusgranarius* in the three market of Kwali Area Council of FCT-ABUJA

KWALI AREA COUNCIL	WBL	BW	HL	FL	H	A	T	WF	F
Dafa market	107.92^{abcd}	34.90^{ab}	54.89^{b}	43.91^{a}	41.48$^{a\,b}$	23.61^{a}	11.09^{a}	8.72^{b}	24.29^{a}
Kwali market	98.61^{cd}	34.38^{ab}	54.33^{b}	49.01^{a}	40.89^{ab}	18.84^{b}	15.32^{a}	7.46^{b}	24.65^{a}
Kaota market	94.36^{d}	34.04^{ab}	57.15^{b}	57.44^{a}	35.97^{ab}	24.96^{a}	12.32^{a}	6.41^{b}	23.88^{a}
SE±	7.68	1.93	8.6	12.14	3.08	2.61	2.73	1.54	3.92

Means with the same letter(s) in the same column are not significantly different by Duncan Multiple Range Test (DMRT) at 5% level of probability

KEY: WBL= Whole body length, BW= Body width, HL= Hind limb, FL= Fore limb, H= Head, A= Antennae, T=Tarsi, WF= Width of femur, F= Femur.

Table 6: Morphometric diversity of *sitophilus granarius* in the Five Area Council of FCT-ABUJA

TREATMENT	WBL	BW	HL	FL	H	A	T	WF	F
KUJE	111.03^{a}	35.29$^{a\,b}$	57.60^{b}	60.45^{a}	39.92^{a}	24.83^{abc}	13.59^{a}	8.36^{a}	22.66^{a}
GWAGWALADA	109.60^{a}	35.92^{a}	56.94^{b}	60.55^{a}	40.31^{a}	26.67^{a}	12.94^{a}	7.59^{a}	23.68^{a}
AMAC	109.37^{a}	34.65^{ab}	67.66^{a}	57.67^{a}	39.19^{ab}	25.23^{ab}	12.04^{a}	6.95^{a}	24.72^{a}
ABAJI	107.55^{ab}	33.72^{b}	56.30^{b}	54.49^{a}	36.57^{b}	22.91^{bc}	13.38^{a}	6.85^{a}	24.33^{a}
KWALI	100.30^{b}	34.44^{ab}	55.46^{b}	50.12^{a}	39.45^{ab}	22.47^{c}	12.91^{a}	7.53^{a}	24.27^{a}
SE±	2.77	1.39	2.93	3.48	1.75	1.62	1.65	1.98	

Means with the same letter(s) in the same column are not significantly different by Duncan Multiple Range Test (DMRT) at 5% level of probability

KEY: WBL= Whole body length, BW= Body width, HL= Hind limb, FL= Fore limb, H= Head, A= Antennae, T=Tarsi, WF= Width of femur, F= Femur.

4. Discussion

The diversity in the features of *Sitophilus granarius* measured were obvious which showed variation. *Sitophilus granarius* in Kuje main market of Kuje area council had the longest whole body length (114.62mm) and the longest body width, while the shortest width of femur was recorded in Rubochi at Kuje Area Ccouncil. The longest whole body length (116.10mm) of the insect *(Sitophilusgranarius*) was recorded in gwagwalada market of Gwagwalada Area Council.The longest body width (36.73mm) and hind limb (61.53mm) was also recorded in Zuba market of Gwagwalada area council. In Abuja Municipal Area Council (AMAC), the *Sitophilus granarius* in Karimu Market had the shortest hind limb(54.12mm) and Deidei market had the shortest fore limb (55.34mm). Agyana market in Abaji Area Council had the shortest antennae (18.82mm). The shortest forelimb of *sitiophilusgranarius*was recorded in Abaji market (47.10mm)compare to other market of Abaji Area Council. In Kwali Area Council, the *Sitophilus granarius* in Kaota market had the shortest whole body length (94.36mm) compare to other market while the *Sitophilus granarius* in Kwali market had the shortest antennae at Kwali Area Council. This research work agreed with the findings of Alabere, 2018 and Ndanusa, 2017 who reported that the features of *Sitophilus* measured were obviously different from one another despite no much significant different, but there were still variations among the species.

5. Conclusion

Based on the above results, in Kuje Area Council, Kuje market had the highest features among the features of insect measured.Gwagwalada Area Council did not show any diversification among *Sitophilus granarius* in the three markets. In Abuja Municipal Area Council (AMAC), Gosa and Karimu markets showed diversification among the features of *Sitophilus granarius* measured. No significant difference was recorded for Fore limb, Tarsi, Width of femur and Femur among the Area Councils surveyed. Result obtained indicated that Kuja and Abaji Area Council had varied diversity of features of *Sitophilus granarius* and only *Sitophilus granarius* was identified in all the five Area Councils of FCT-Abuja, Nigeria.

Recommendations

Further studies should be carried0out on *Sitophilus granarius* in other markets in FCT-ABUJA toward discovering new species of *Sitophilus* and Entomologist could used the differences in features of the insects measured to obtained different species or genus of *Sitophilus granarius.*

References

Alabere, A., 2018. Morphometric and Identification of maize weevil in Selected Local Government of Kwara State. Undergraduate project, Federal University of Technology, Minna, Niger State, Nigeria.

FAOSTAT, 2013. Statistical databases and data sets of the food and Agricultural Organization of the United Nations. Available at: http://faostat3.fao.org/home/index.html. DOWNLOAD [Accessed February 17, 2019]

FAOSTAT, 2014. Maize production in 2014, crops/region/production quantity from pick lists. United Nations, Food and agricultural Organization, Statistics Division.

Fran, H., 2012. Global corn demand to grow 2.2% a year. Available at: http://www.agweb.com/article/global corn demand to grow 2.2 a year/[Accessed February 14,/BC].

Gupta, H.S., Hossain, F., Muthusamy, V., 2015. Biofortification of maize: An Indian perspective. *Indian Journal of Genetics and Plant Breeding*, 75 (1), Pp. 1-22. http//dx.doi.org/10.5958/0975-6906.2015.00001.2

Hodges, R.J., 2012. Post-harvest weight losses of cereal grains in Sub-Saharan Africa.http://www.erails.net/FARA/aphlis/aphlis/weight-losses-review/, accessed on 11th December 2017.

Howe, R.W., 1968: *Sitophilus granarius* (L.) (Coleoptera, Curculionidae) breeding in acorns. *Journal of. Stored Product Research,* 1, Pp. 99-100.

IITA. 2009. International Institute of Tropical Agriculture, Ibadan, Oyo State.Annual Report on Maize production.

Kamanula, J., Gudeta, W., Mvumi, S., Nyirenda, B.M., Greenwell, K.C., Nyirenda, S.P., Tevenson, C.P., 2011. Farmers' insect pest management practices and pesticidal plant in the protection of stored maize and beans in Southern Africa. *International Journal of Pest Management,* 59, Pp. 41–49.

Ndanusa, 2017. Morphometric Identification of maize weevil Morphometric and Identification of maize weevil in Selected Local Government of Kwara State. Undergraduate project, Federal University of Technology, Minna, Niger State, Nigeria.

Ogunsina, O.O.M.O., and Lajide, L., 2011. Insecticidal action of hexane extracts of three plants against bean weavil, *Callosobruchus maculatus* (F.) and maize weevil, *Sitophilus zeamais* Mitch. *Journal of Ecology and Natural Environment,* 3, Pp. 23-28.

Onuk, E.G., Ogara, I.M., Yahaya, H., Nannim, N., 2010. Economic Analysis of Maize
Production in Mangu Local Government Area of Plateau State, Nigeria. Nasarawa State University Keffi, 6 (1), Pp. 1 – 11.

Prathyusha, C., Hemalatha, S., and Sharana, B., 2013. Growth and Productivity of Speciality Corn as influenced by different levels of

Nitrogen under Pongamia Plantations. *International Journal of Applied Biology and Pharmaceutical Technology,* 4, (4).

Richards, O.W., 1947. Observations on grain weevils Calandra (Coleoptera: Curculionidae). I. General biology and oviposition. Proceedings of the Zoological Society of London, 117, Pp. 1-43.

Sagheer, M., Khaliq, A., Khan, F.Z.A., Gul, H.T., Ahmad, K., 2013. Assessment of relative resistance in advanced rice genotype in response to variation in abiotic factors and development of *Triboliumcastaneum* (Herbst) (Coleoptera:Tenebrionidae). *International Journal of Biosciences*, 3, Pp. 33 - 38.

Tefera, T., Mugo, S., Likhayo, P., 2011a. Effects of insect population density and storage time on grain damage and weight loss in maize due to the maize weevil, Sitophiluszeamais and the larger grain borer, *Prostephanus truncatus. African Journal of Agricultural Research*, 6, Pp. 2249–2254.

USDA, 2013. Corn, in: Grain inspection handbook - Book || Grain Grading Procedures. United States Department of Agriculture, Grain inspection, Packers and stockyards Administration, Federal Grain Inspection Service, Pp. 4 – 12.

Yohannes, A., Aseyew, G., Melaku, G., Derbew, S. Kefir and Raja, N., 2014. Evaluation of certain plant leaf powders and aqueous extracts against maize weavil, SitophiluszeamaisMotsch. (Coleoptera: Curculionidae). *Asian Journal of Agricultural Sciences,* 6, Pp. 83 - 88.