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EXPLORING THREE PLANT POWDERS AS A STRATEGY FOR SUSTAINABLE MANAGEMENT OF MAIZE WEEVIL (*Sitophilus zeamais*) IN STORED MAIZE GRAINS.

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ABSTRACT

Maize has become the primary staple food among household of different wealth worldwide especially in Africa, yet most of the yields are lost to insect infestations during storage, especially *Sitophilus zeamais*. The insecticidal effect of Neem seeds, Garlic bulb and Chilli pepper powders were tested on adult weevil establishment,

Introduction

Maize (*Zea mays* L.) is originated in central Mexico from a wild grass and was introduced to Nigeria in 16th century (Ranum *et al.*, 2014 and FAOSTAT 2014). It is one of the most important cereals crop in the world both as food for man and feeds for animals; therefore it's referred to as 'queen of cereals' because of its high yield potential (Nand, 2015).

Maize is the second most cultivated crop in Nigeria, in terms of area harvested (5.8million Ha, second to Cassava's 7.1 million Ha). Nigeria is the second largest maize producer in Africa, after South Africa and the 10th largest producer in the word, with an estimated 10.79 million MT produced in 2014 (Hartwich *et al.*, 2010 and FAOSTAT 2014). The largest volumes of maize are produced in the Northern region, particularly in Kaduna, Borno, Niger, and Taraba and in the South-Western

mortality, oviposition and subsequent emergence after treatment and to determine the synergetic effects of the three botanicals on the weevils.The study was carried out in Federal College of Forestry, Jos Laboratory using a 3×3 factorial experiment laid in a Completely Randomized Design (CRD) and was replicated three times. The result showed that weevils were able to establish in all the treatments. Adult mortality increases as the duration increases with dosage 10, 15, 20 grams and the combination had similar mortality. However, analysis of variance showed no significant difference among 10, 15, 20 grams and combination but significantly different from the control at 48 days after treatments. The few weevils that survive were able to oviposite and this decreases as the dosage increases in all plant powders, with the control recording the highest oviposition values and least value recorded in the combination treatment. Notwithstanding, analysis showed no significant difference. Weevil emergence decreases as the dosage increases in all the plant powders with the control recording the highest values (28.33%), while combination recorded the least values (6.67%) and these was significantly different analytically. The resultant effect was significant difference on the weight loss with the control having the high weight loss. Based on this study, it could be concluded that the combinations of powders and Neem seed powder could be used as an effective control of *Sitophilus zeamais* at dosage 20g/100g of maize grain respectively.

Keywords: Plant powder, Maize weevil, Establishment, Mortality and Oviposition.

states including in Ogun, Ondo and Oyo. It is the fourth most consumed cereal during the past two decades, below sorghum, millet and rice (FAOSTAT 2014). Being among the primary food staples, maize consumption is widespread across the country and among households of different wealth. Most of the national production aims at human consumption for the production of some local foods such as; pap, tuwo, gwate and donkunu, with the cereal cooked,

roasted, fried, ground, pounded or crushed form (Abdulrahama and Kolawole, 2006).. However, industrial uses (such as the brewery and feed industry) have been developing in the past decades; the percentage of total maize production used for feed has grown from 13 to 18 percent of total production (USDA, 2010). A specific driver of the feed industry is the development of the poultry sector, as poultry feed represents 95-98 percent of the total feed produced in the country between 2005 and 2010 (USDA, 2010).

Nutritionally, it contains approximately 72% starch, 10% protein and 4% fat, supplying an energy density of 365 Kcal/100 g (Ranum *et al.,* 2014). In addition, it has higher content of protein and fat as compared to other cereals such as millet, sorgum, wheat etc. It also contain vitamin B complex such as B1 (thiamine), B2 (niacin), B3 (riboflavin), B5 (pantothenic acid) and B6. Furthermore, it contains vitamin A, C and K together with large amount of beta carotene and fair amount of selenium that helps to improve thyroid gland and play important role in proper functioning of immune system (Kumar and Jhariya 2013).

Despite its high production value, Nigeria's average maize yield of 1.8 MT/Ha is one of the lowest among the top 10 maize producers in Africa. It lags behind countries such as Egypt and South Africa where the yields are 7.7MT/Ha and 5.3MT/Ha respectively (FAO, 2008). This could partly due to the existence of low capacity stores, use of local mud bins for storage, un-cleaned and filthy store houses, improper ventilation, leaky and dampness in store houses, inconvenient storages (with broken walls, ceilings and floors) are some of the serious but less noticeable storage problems. The situation is further compounded when storage is done in open areas where insect pests, rodents and birds cause lots of damage (Tunio, 2012). It is estimated that 50% grain production is lost due to improper storage and attack of insects pests in tropical countries including Pakistan and Nigeria. (Adedire, 2001).

Maize weevil (*Sitophilus zeamais*) is a major pest of stored maize grains in the tropics and temperate regions of the world (Sagheer *et al.,* 2013; and Adedire, 2001, Akob and Ewete, 2007). According to (Yohannes *et al.,* 2014) the estimated global annual losses due to pest's activity in the field and storage are

valued more than $100 billion. The attack may start in the mature crop on the field when the Moisture Content (MC) of the grain had fallen to 18-20% (Radha, 2014). In stored maize, heavy infestation of this pest may cause weight losses of as much as 30-40% (Radha, 2014; Ogunsina *et al.,* 2011).

Stored-product pests are particularly important because they attack the final agricultural product, therefore it is very important to carry out an investigation to curb the menace of weevil infestation. At present, pest control measure in storage rely heavily on the use of synthetic pesticide and fumigants (Ogunsina *et al.,* 2011), this causes some deleterious health hazard to farmers and the consumer hence; the use of botanical that are human friendly and less hazardous to replace synthetic pesticides is necessary.

Many African plants are potential source of pesticide and have been shown to contain either anti-feedant, repellent or insecticidal compound that enable the crude plant materials or an extract active compound to protect stored product by killing the insects (Oladejo, *et al.,* 2020). For example neem seed produce oil and powder that alter the hormone of bugs so that they cannot fly, breed or eat (Kubo and Nakanish, 2001), Garlic extract on the other hand show considerable toxicity to a number of pest species, across all life stages while Capsaicin (Chili pepper) has repellent and insecticidal properties for all species of pest (Mousa *et al*., 2013). The phytochemical constituents of these plants as shown below reveal their insecticidal properties (Mohammad and Idris, 2019; Sujata, 2021 and Gayathri *et al.,* 2016). Therefore the objective of this study is to determine the effects of these three medicinal plants on maize weevil.

Phytochemical	Aqueous Extract	Ethanol Extract
Alkaloids	+	+
Flavonoid	+	+
Glycosides	+	+
Reducing sugar	-	-
Saponin	+	+
Steroids	+	+
Phenols	+	+
Terpenoid	+	+
Anthraquinones	+	+
Tannin	+	+

Phytochemical Constituent of Garlic Bulb (Mohammad and Idris, 2019)

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Alkaloids	+
Saponins	+++
Tannins	++
Steroid	+++
Terpenoid	+++
Glycoside	++
Flavonoid	+
Phenol	+
Oxalic acid	+

+++: Most present; ++: Moderately present; +: Least present

Phytochemical Constituent of Neem seed (Sujata, 2021)

Carbohydrate	**-**
Tannis	**-**
Saphonins	**++**
Flavonoids	**++**
Cardiac glycosides	**-**
Phenols	**+++**
Steroids	**-**
Alkaloids	**++**
Terpenoid	**+**
Anthroquinones	**-**
Volatile oils	**+**

Phytochemical Constituent of Chilli pepper (Gayathri et al., 2016)

MATERIALS AND METHODS

Study Area

The experiment was carried out in Entomology laboratory of Federal College of Forestry Jos. Jos North Local Government area of Plateau State is located at north Central zone of Nigeria. Jos is situated between latitude 9° 50'N and

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10° 05'N and longitude 8° 50'E and 8° 55'E. It is in highland area that project from plain of central and northern Nigeria. It average temperature range from 20.2°C to 34.3°C (Kowal and Knabe 2019).

Source of maize seeds

About 3kg maize grains were purchased from Terminus market. The grains were sieved to remove non viable seed, dirty and broken particles. Then, 2.5kg grains was randomly sampled and stored in a refrigerator for two weeks to kill any prior sources of the maize weevil inoculum and eggs which might be already pre-existing in the grain as procedure (Parugrug and Roxas 2008).

Plant powders preparations

Neem seeds were collected from neem tree found in Tilde in Bauchi. Garlic bulb and chili pepper will be purchase from Terminus market. Each of these were properly cut into smaller pieces with a sharp blade and dried at room temperature, to avoid loss of active compounds through photo degradation of active ingredient by ultra-violet ray (Salako 2008). The dried materials were then be ground into fine powder using blender and sieved with a 10mm sieve. The fine powders were kept in air-tight containers until required.

Sampling Method

100g of dried maize grains was treated with 10g, 15g, and 20g of each of the test treatment in 12 cm high x 6.5 cm diameter glass jars. In the first treatment neem seed powder; in the second tratment garlic bulb powder, in the third treatment chilli pepper powder, and in the forth treatment admixture of neem seed, garlic bulb powder and chilli pepper powder was used. The admixtures were shaked manually for 5 minutes and the treated maize grains were undisturbed for an hour. Mixture of 10 adult maize weevils of about 24hours (1:1 male, female ration) was introduced per treatment. The glass jars was covered with Muslin net of about 0.02mm and sealed with rubber ring to prevent the insects from escape. Untreated maize served as control for each. Each treatment was replicated three times.

Test for Weevil Establishment

Weevil establishment was checked through their body movement after 8hours of introducing the plants powder into the maize grain.

Test for Weevil Mortality

Weevil mortality rates was observed by physically counting dead weevils at 24hours to 120hours exposure to the treatment, any weevil that cannot move up to half of it's body length is assumed to be dead (Oladejo *et al.,* 2020).

Test for Weevil Ovipostion

After 120 hours, oviposition was checked by removing all the dead weevil and each grain was carefully observed for a transparent dot or black dot inside the grain using hand lens or Light microscope (sign of laid egg on maize grain)

Test for Weevil Emergence

The treatment was then kept for 35days, to observe the new emergence of maize weevil, which commenced on the 30th days after oviposition.

Statistical analysis

Data was collected and analysed using ANOVA to determine whether there is significant between the treatment,and Least Significant Difference (LSD) test was later used to separate the mean.Using SPSS software version 23.

RESULTS

Weevil Establishment

Weevils were able to establish after eight hours of introducing the plants powders and was observed through their body movement.

Weevil Mortality

Table 1: Illustrates adult weevil mortality after 120 hours of exposure. It was observed that mean mortality increases as both dosage and duration of the experiment increases, except for control treatment that remains constant.

Analysis of the overall data show a significant difference between different dosages applied to the weevil's environment and duration, but no significant difference were observed between different plants powder used. However, LSD further revealed the factor that is responsible for the difference (Table 1).

Table 1: Mean adult mortality after 24, 48, 72, 96 and 120 hours of exposure to different plant powders

Plants Powder	Dosages.	24hours	48 hours	72 hours	96 hours	120 hours
Garlic Powder	0g/ Control	0.00[a]	0.00[a]	0.00[a]	0.00[a]	0.00[a]
	10g	0.00[a]	6.67[b]	10.00[b]	16.67[b]	16.67[b]
	15g	6.67[b]	10.00[d]	16.67[d]	16.67[b]	16.67[b]
	20g	20.00[c]	13.33[c]	13.33[c]	20.00[c]	16.67[b]
	SE ±	0.976	1.164	1.263	1.209	1.171
Pepper Powder	0g/ Control	0.00[a]	0.00[a]	0.00[a]	0.00[a]	0.00[a]
	10g	0.00[a]	6.67[b]	13.33[b]	16.67[b]	20.00[c]
	15g	6.67[b]	13.33[c]	16.67[c]	16.67[b]	20.00[c]
	20g	16.67[c]	16.67[d]	16.67[c]	16.67[b]	13.33[b]
	SE ±	5.833	1.164	1.263	1.209	1.171
Neem Powder	0g/ Control	0.00[a]	0.00[a]	0.00[a]	0.00[a]	0.00[a]
	10g	3.33[b]	10.00[b]	13.33[b]	13.33[b]	16.67[c]
	15g	6.67[c]	13.33[c]	13.33[b]	16.67[c]	16.67[c]
	20g	20.00[d]	13.33[c]	16.67[c]	20.00[d]	10.00[b]
	SE ±	7.500	1.164	1.263	1.209	1.171
15g Garlic + 15g Pepper + 15g Neem Powder	0g/ Control	0.00[a]	0.00[a]	0.00[a]	0.00[a]	0.00[a]
	10g	6.67[b]	10.00[b]	13.33[b]	16.67[b]	16.67[c]
	15g	10.00[c]	16.67[c]	16.67[c]	16.67[b]	16.67[c]
	20g	20.00[d]	16.67[c]	16.67[c]	16.67[b]	13.33[b]

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	SE ±	9.167	1.164	1.263	1.209	1.171

(*Mean with the same alphabet in the same column are not significant (p ≤ 0.05)*

Effects of each plant materials on the oviposition.

Table 2 shows the values obtained from oviposition of weevils in the experimental setup. Oviposition of weevils decreases as the dosages increases in all the plant powders applied, with the control recording the highest oviposition values, while the least values (48.83 each) was observed in the combination treatment (15g Garlic + 15g Pepper + 15g Neem Powder) (21.40). However analysis of variance shows no significant difference.

Table 2: Effect of plant powders at different concentrations on the oviposition of weevil.

Different Dosages	Garlic Powder	Pepper Powder	Neem Powder	Combination of the Powders
0g/ Contr	48.83	48.83	48.83	48.83
10g	34.50	33.90	33.70	32.87
15g	30.80	30.23	29.40	26.10
20g	23.30	22.30	23.03	21.40
SE ±	0.31	0.33	0.30	0.31

Effects of each plant materials on the Weevil emergence.

On weevils emergence, the result is presented in table 3. Weevils emergence decreases as the plant powders increases in all the treatments, with the control recording the highest values (28.33 each), while the least values (6.67each) was observed in the combination treatment (15g Garlic + 15g Pepper + 15g Neem Powder).

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Table 3: Effects of plants powder at different dosages on weevils emergence.

Different Dosages	Garlic Powder	Pepper Powder	Neem Powder	Combination of the Powders
0g/ Control	28.33	28.33	28.33	28.33
10g	11.67	13.00	12.33	11.33
15g	10.00	10.33	10.67	10.67
20g	9.67	9.33	9.33	6.67
SE ±	0.57	0.58	0.54	0.57

Check for the weight loss after the emergence of the weevil.

Table 4 shows the values obtained from weevils weight loss in the experimental setup. weevils weight loss decreases as the plant powders increases in all the treatments, with the control recording the highest values (14.67each), while the least values (5.33each) was observed in the combination treatment (15g Garlic + 15g Pepper + 15g Neem Powder).

Table 4: Effects of plants powder at different dosages on maize weight loss.

Different Dosages	Garlic Powder	Pepper Powder	Neem Powder	Combination of the Powders
0g/ Control	14.67	14.67	14.67	14.67
10g	7.23	8.00	7.37	7.43
15g	7.03	7.07	7.03	6.83
20g	7.07	6.97	7.03	5.33
SE ±	0.28	0.23	0.24	0.27

DISCUSSION

The efficacy of the botanicals on the *Sitophilus zeamais* were significantly different, the effects of different plant materials on insects may depend on

several factors such as chemical composition and species susceptibility (Aktar *et al.,* 2004). The preponderance of tannins, steroids, anthraquinones and cardiac glycoside in the three plant powders may suggest a role in its pesticidal and anti-feedant potencies against some insect and pathogens (Mila, *et al*., 1996; Thomas and Krishnakumari, 2015). In the present study, mortality of *S. zeamais* varied with the dosage of the plant species. This finding showed that an increase in the botanical dosages results in a reduction in the incidence of weevil attack. This agrees with the work of Mbaiuinam *et al., (2006*) where Neem powders and Garlic bulb powders showed that grounding the plants allows them to release their insecticidal effect on weevils. The untreated grain offers free environment where weevils suffer no developmental limitations hence the highest feeding rates. However greatest effectiveness of the botanical pesticides was observed at the combination of the three medicinal plants.

The highest mortality in all the treatment was recorded on the 4th day after treatment except the control that had 0.00%1c. This agreed with Berhanu and Emana (2018), Ibrahim and Sisay, (2012) who recorded significantly higher mortality of maize weevils 4 days after treatment exposure in all treatments of integration and other tactics tested at 5 and 10% doses using Neem powder and garlic bulb powder. Also, with combinations of different rates of Malathion5% dust and neem seed powder, higher significant weevils' mortality was recorded when compared with untreated maize grains.

The weevil were able to oviposite more on the control than those with botanicals, where the control has the highest percentage of oviposition with 48.83% and those that have botanicals has the least of 21.40%. This study revealed that all the selected botanicals had negative effects on egg laying by *Sitophilus zeamais* in stored maize grains. Oviposition by *S. zeamais* was significantly lower in powded grains than in untreated grains. This comfirm the report of Khaliq *et al., (*2014) and Edeldouk *et al., (*2012) who concluded that plant powders reduce oviposition of weevils from 25.75% in controls to 18.50% and 25.5 to 1.25% respectively in Neem seed powder applied at the concentration of 3.0 g / 50 g maize grains after 1 month post treatment.

Similarly, Ileke (2014) reported a reduction in the number of eggs laid by *S. zeamais* from 36.25 ± 2.27 in the control to 8.00 ± 0.91 in the combination of Neem seed powder, garlic bulb powder and chili pepper powder applied at 0.4 ml / 20 g maize grains. Effectiveness of Neem seed powder in reducing egg deposition by *S. zeamais* concurs with Kosar *et al.,* (2016) who reported ovipositional deterrence of Chilli pepper powder and Neem seed powder against *S. zeamais.*

Weevils emergence decreases as the concentration increases in all the plant powder applied,with the control recording the highest values (28.33% each),while the least values was observed in the combination treatments (6.67% each). Outcomes of this study have revealed that all the botanicals tested had total inhibition rate in adult emergence o*f S. zeamais* in maize grains treated with powders of Neem seed powder, chilli pepper powder and Garlic bulb powder as there was least adult emergence recorded compare to the untreated maize. However, garlic bulb powders of the botanicals were found to be less effective than the other formulations, even though the incident rate was very high compared to the control. The use of plant powders in suppressing adult emergence of *S. zeamais* was previously reported by others ((Edeldouk *et al.,* 2012; Ojo and Ogunleye 2013 and Rivera *et al.,* 2014). Performance of plant powders of the study botanicals in reducing adult emergence of *S. zeamais* agrees with the findings of (Oni and Ogungbite 2015) who reported that botanical powders of Chilli pepper powder, Neem seed powder and Ginger powder inhibited 28.76 ± 0.33 to 94.13% ± 1.06 adult emergence of *S. zeamais* in stored maize. Similarly, (Edelduok *et al.,* 2015) recorded 0.50 adult emergence of *S. zeamais* in maize grains treated with cotyledon powder of Neem seed powder at the rate of 3.0 g / 50 g at 21 days after treatment. Complete suppression of adult emergence of *S. zeamais* by plant powders of Chilli pepper powder and Neem seed powder of the botanicals achieved in this study is in accordance with (Ojo and Ogunleye 2013). They reported that plant powders of ginger powder and chilli pepperpowder completely suppressed the emergence of *S. zeamais* 42 days after introducing the weevils in the treated maize grains. Similarly, (Rivera *et al.,* 2014)reported

none emergence of adult *S. zeamais* in maize treated with Neem seed powder at 1.0% .The present study has found that Neem seed powder was more effective than the other botanicals, while untreated maize (control) recorded more emergence than others. Total inhibition rate in adult emergence of *S. zeamais* in maize treated with combination of Neem seed powder, chilli powder and garlic bulb powder at varying concentrations was achieved. This outcome is in line with the findings of (Ileke *et al.,* 2014) who recorded complete inhibition of adult emergence of *S. zeamais* after 30 days of exposure to plant powder of Neem seed powder applied at 0.4 ml / 20 g maize. Similar result was obtained by (Oni and Ogungbite 2015) that 6, 8 and 10% powder of chilli pepper powder caused 80% inhibition rate in adult emergence of *S. zeamais* in stored maize 42 days after treatment.

The grain weight losses were significantly different from the control and those grains with botanicals, control has the highest weight loss value of 14.67 while the least recorded in the grains with botanicals was 5.33. The low quantity of weight loss observed in this study suggests that combination of this three medicinal plants can be used as good alternative to synthetic pesticides against S.zeamais. According to (Duke 2001) weevils are capable of causing 80-100% weight loss if grain is left untreated for long periods.

Conclusion

In the absence of synthetic chemicals, small holder farmers can use Neem seed powder, chilli pepper powder and Garlic bulb powder to lowered the weevil damage. The powders also have a tendency of blocking the spiracles of the insect thus impairing respiration leading to their death.

It can be concluded from the present study that combinations of powders and Neem seed powder could be used as effective insect control. Based on high rate of control effects, neem seed and combination powders at 20g/100g of maize grain can be used as control for damage caused by maize weevil (*Sitophilus zeamais*). Hence, the use of neem seed, chilli pepper and garlic powders as an alternative control option in integrated storage pest management strategies by small holder farmers.

Recommendation.

- This study revealed that the insecticidal efficacy of the three plant seed powders were concentration dependent, therefore, a standardized method of concentration formulation should be established.
- Also, further studies should be carried out at high concentration of the powders.

REFERENCES:

Abdulrahaman, A. A. and Kolawole, O. M. (2006). Traditional Preparations and Uses of Maize in Nigeria Ethnobotanical Leaflets 10: 219-227. C:\Users\cadoni\Documents\MAFAP\MAIZE NIGERIA\Literature\TRADITIONAL PREPARATIONS AND USES OF MAIZE IN NIGERIA.

Adedire, C.O., (2001). *Biology, Ecology and Control of Insect Pests of Stored Grains.* In: Pest of Stored Cereals and Pulses in Nigeria, Ofuya, T.I. and N.E.S. Lale (Eds.). Dave Collins Publications, Nigeria, pp: 59-94.

Akob, C.A. and Ewete, F.K. (2007). The development and field infestation of Sitophilus zeamais Motschulsky (Coleoptera: Curculionidae) on maize in the western highlands of Cameroon. *Journal of the Cameroon Academy of Sciences* 7(2):77-84.

Aktar, Y. and Isman, M.B. (2004) Comparative growth inhibitory and antifeedant effects of plant extracts and pure allelochemicals on four phytophagous insect species. *Journal of Applied Entomology* 128(1): 32-38.

Berhanu, H. and Emana G (2018). Efficacy of integration of three management tactics relative to unitary tactics against Maize weevil, Sitophilus zeamais (Motschulsky) (Coleoptera: Curculionidae) of stored maize in Ethiopia. *Journal of Stored Products and Postharvest Research* 9(2): 8-15.

Duke, J.A. (2001). Handbook of medicinal herbs CRC press, Bocd Raten, FL, USA, pp. 114-128.

Edeldouk, E.; Akpabio, E.; Eyo, J. and Ekpe, E. (2012). Bio-insecticidal potentials of testa powder of melon, Citrullus vulgaris Schrad for reducing infestation of maize grains by the maize weevil, Sitophilus zeamais Motsch. *Journal of Biology and Agricultural Healthcare.* 2(8): 13-17.

Edelduok, E.G., Apkabio, E.E., Eyo, J.E. and Ekpe, E.N. (2015). Evaluation of the insecticidal activities of cotyledon powder of melon, Citrullus vulgaris Schrad against the maize weevil, Sitophilus zeamais Motschulsky. *Journal of Biological pesticides and Environment* 1: 50-57

Food and Agricultural Organization (FAO).(2008). Post-harvest grain loss assessment methods-a manual of methods for the evaluation of post-harvest losses. FAO, Rome.

Food and Agricultural Organisation Statistics (FAOSTAT) (2014). Online statistical database (retrieved November 2014) (available at http://faostat.fao.org).

Gayathri, N.; Gopalakeishnan, M and Sekar, T. (2016). Phytochemical screening and antimicrobial activity of *Capscicum chinense* Jacq. International Journal of Advances in Pharmaceutics. Vol.5:1.

Hartwich, J. D.; Kormawa, I.D.; Bisallah, B.O. and Odufote I.M. (2010). Polycarp "Unleashing Agricultural Development in Nigeria through Value Chain Financing", UNIDO.

Ibrahim, A.Y. and Sisay, A. (2012). Farmers' practices and combinations of Malathion and neem seed powder management options against sorghum and maize insect pests during Storage at Bako, West Shoa Zone, *Ethiopia East Africa Journal of Science.* 6: 55-64.

Ileke, K.D. (2014). Cheese wood, Astonia boonei De Wild a botanical entomocides for the management of maize weevil, *Sitophiluszeamais* Motschulsky (Coleoptera: Curculionidae). Octa *Journal of Biological sciencies.* 2(2): 64-68.

Khaliq, A., Nawas, A., Ahmad, N.H. and Sagheer, M. (2014). Assessment of insecticidal potential of medicinal plant extracts for control of maize weevil, Sitophilus zeamais Motschulsky (Coleoptera: Curculionidae). Basic Resources. *Journal of Agricultural Science.* Rev., 3(11): 100-104.

Kosar, H. and Srivastava, M. (2016). Euphorbiaceae plant extracts as ovipositional deterrent against Callosobruchus chinensis Linn (Coleoptera: Bruchidae). *Journal of Biological pesticides.* 9(1): 80-90

Kowal, J.M and Knabe, D.T. (2019). An agro-climatology Atlas of the Northern State of Nigeria. Ahmad Bello University Press, Zaria.

Kubo, I. and Nakanish, K. (2001). Insect and anti-feedant and repellent from African plant in symposition series No.62: host plant resistant to pests. The America chemical society Pp.165-175.

Kumar, D. and Jhariya, A.N. (2013). Nutritional, medicinal and economic importance of corn: a mini review. *Research Journal of Pharmaceutical Science*. 2:7-8.

Mbaiguinam, M.; Naura, N.; Bianpambe, A.; Bono, G. and Alladcumbaye, E. (2006). Effects of commom plant seed oils on survival, eggs lying and development of the cowpea weevil, *Callosobruchus maculantus* (F.) Coleoptera: brychidae. *Journal of Boll School*. 6: 420-425.

Mila, I.; Scalbert, A and Expert, D. (1996). Iron withholding by plant polyphenols and resistance to pathogens and rots. *Phytochemistry* 42: 1551-1555.

Mohammad, A and Idris, S. I. (2019). Phytochemical Screening and Proximate Analysis of Garlic (*Allium sativum*) Archives of Organic and Inorganic Chemical Sciences. Vol.4:1 lupinepublishers.com/chemist

Mousa, K.M.; Khodeir, I.A.; El-Dakhakhni, T.N. and Youssef, A.E. (2013). Effect of Garlic and Eucalyptus oils in comparison to Organophosphat insecticides against some Piercing-Sucking Faba bean insect Pests and natural enemies' populations. Egyptian Academic *Journal of Biological Sciences* 5 (2): 21 -27.

Nand, V. (2015). Effect of spacing and fertility levels on protein content and yield of hybrid and composite maize (Zea mays L.) grown in rabi season. *Journal of Agriculture and Veterinary Science.* 8(9):26-31.

Ogunsina, O.O.; Oladimeji, M.O. and Lajide, L. (2011). Insecticidal action of hexane extracts of three plants against bean weevil, *Callosobruchus maculatus* (F.) and maize weevil, *Sitophilus zeamais* Motsch. *Journal of Ecological and National and Environment*. 3: 23-28.

Ojo, D.O. and Ogunleye, R.F. (2013). Comparative effectiveness of the powders of some underutilized botanicals for the control of Sitophilus zeamais (Motschulsky) (Coleoptera: Curculionidae). *International Journal of Pure and Applied Science Technology*, 16(2): 55-62

Oladejo A.O., Sikiru G.K., Popoola A.S., Adedire O., and Olorioke. (2020). Insecticidal effects of Gimelina Arboreal stem Bark and leaf powder on *sitophilus zeamais* [Maize weevil) on store Zeamays (Maize) Grain. *African Scholar Journal of African Sustainable Development* (AJASD), vol. 18 No.2.Pp 225 – 234.

Oni, M.O.and Ogungbite, O.C. (2015). Entomotoxicant potential of powders and oil extracts of three medicinal plants in the control of Sitophilus zeamais infesting stored maize. *Journal of. Plant and Pest Sciences.* 2(1): 8-17.

Parugrug, M.L. and Roxas, A.C. (2008). Insecticidal Action of Five Plants Against Maize Weevil, Sitophilus Zeamais Motsch. (Coleoptera: Curculionidae). *KMITL Science Technology Journal*. 8(1): 23-38.

Radha, R. (2014). Toxicity of three plant extracts against bean weevil, *Callosobruchus maculatus* (F.) and maize weevil, *Sitophilus zeamais* Motsch. *International Journal of Current Resources*. 6: 6105-6109.

Ranum, P.; Pena-Rosas, J.P. and Garcia-Casal, M.N. (2014). Global maize production, utilization and consumption. Annals of the New York Academy of Sciences. 2014; 1312(1):105-112.

Rivera, P., Silva, G., Figueroa, I.; Tapia, M.; Rodriguez, J.C.; Jose, A.R. and Adesina, J.M.(2014). Oviposition infestation deterrent and phytochemical screening of *Heliotrpium indicum* and *Lawsonia inermis* against *Callosobruchus maculatus* Fabricius (Coleoptera:Chrysomelidae) on cowpea seeds. *Int ernation Journal of Molecular Zoology*. 4(1):1-8.

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

Salako, E.A. (2008). A review of neem biopesticide Shadia utilization and challenges in central Nigeria.

Sujata, K. (2021). Qualitative and Quantitative Phytochemical Screening of *Azadirachta indica* Juss. Plant Parts *International Journal of Applied Science and Biotechnology. Vol 9(2): 122-127.*

Thomas, R.A. and Krishnakumari, S. (2015). Phytochemical Profiling of *Myristica fragrans* Seed Extract with Different Orgaic Solvents. *Asian Journal of Pharmaceutical and Clinical Research* vol8, issue 1.

Tunio, S. (2012). Grain storage problems in Pakistan. Available online at http://www.agrihunt.com/pak-agri-outlook/734-grain-storage-problems-in pakistan/2016/05/17.

USDA (2010). Foreign Agricultural Service, GAIN Report (Global Agriculture Information Network), Nigeria Grain and Feed Annual - Nigeria's Wheat Imports Surge.

Yohannes, A., G. Asayew, G. Melaku, M. Derbew, S. Kedir and N. Raja, (2014).Evaluation of certain plant leaf powders and aqueous extracts against maize weevil, *Sitophilus zeamais* Motsch. (Coleoptera: Curculionidae). *Asian Journal of Agricultural Science*. 6: 83-88.