Research Article **AJAR (2022), 7:112**

American Journal of Agricultural Research (ISSN:2475-2002)

Comparative effectiveness of turmeric (*Curcuma longa*), garlic (*Allium sativum*) and curry leaves (*Ocimum africanum*) against stored insect pest of Maize, (*Sitophilus zeamais Motsch*)

AZEEZ, O.M. AND OKE, E.

Department of Crop and Soil Science, Faculty of Agriculture, University of Port Harcourt, Choba, Port Harcourt, River State

ABSTRACT

The bioactivity of turmeric, garlic and curry oil and powder were evaluated and compared against maize storage pest, Sitophilus zeamais (Motsch.) at $28+2^{0}$C and relative humidity (r.h.) 65+5% in the laboratory. Ten pairs of newly emerged weevils were introduced separately into each of the plastics containing 20 g maize seed treated with plant oil at different concentrations, 0.25%, 0.50% and 1.00% v/v and similarly plant powder at dosage levels of 0.25 g, 0.50 g and 1.00 g of the tested plant parts. Each treatment, including the control comprised four replicates which were laid out 3x3 factorial arrangements in a completely randomized design. Results indicated that oil and powder of curry, and turmeric evoked significant mortality (82.50%) and (81.00%), while garlic powder is equally effective (72.00%) in achieving mortality of the weevil. There was an appreciable reduction in means of exit hole and percent seed damage in treated maize seeds at 0.50% and 1.00% concentrations. Curry had exit hole (12.25 &11.00), turmeric had (12.75&11.75); also lower seed damage was recorded in curry (11.00% & 21.75%), while turmeric had (20.75% &31.00%). There was however corresponding high percent undamaged seed recorded in curry (89.00% & 78.25%) and turmeric (79.25% & 73.25%). All the plant parts tested reduced weight loss in the stored maize seeds when compared with the control. Adult mortality significantly correlated with exit hole (r = 0.381), seed damage (r = 0.0509) and undamaged seed (r = -0.0643). Therefore, 0.50% was lowest concentration at which control was achieved.

Keywords: Bioactivity; Sitophilus zeamais; Mortality; Protectant; Storage, Maize seed

***Correspondence to Author:**
AZEEZ, O.M.
Department of Crop and Soil Science, Faculty of Agriculture, University of Port Harcourt, Choba, Port Harcourt, River State

How to cite this article:
AZEEZ, O.M. AND OKE, E.Comparative effectiveness of turmeric (Curcuma longa), garlic (Allium sativum) and curry leaves (Ocimum africanum) against stored insect pest of Maize, (Sitophilus zeamais Motsch) . American Journal of Agricultural Research, 2022; 7:112.

eSciPub LLC, Houston, TX USA.
Website: https://escipub.com/

INTRODUCTION

Maize was first grown by people in ancient Central America, though introduced into Africa by the Portuguese in the 16th century, where it however becomes the most important staple food crop (Felix, 1997) [21]. It is primarily cultivated for grains and fodder, other local use is geared up to meeting the demand for direct human consumption, baby cereals, breweries, pharmaceutical companies, and other industrial purposes (Iken and Amusa, 2004) [24]. Major sources of starch in industrialize food products, plastics, fabric, adhesives and many other chemical products. Maize has high nutritional value which includes starch (60 – 80%), protein (8 – 12%), fat (3 – 5%), vitamin (70 – 80%), mineral (1 – 2%), fibers (3.1%) and water (13.5%) (FAO, 1992) [20]. Pingali, (2001) [35] reported that a major shift in global cereal demand is underway, the demand for maize in developing countries will surpass the demand for both wheat and rice in the year 2020. The quality of grains and seeds during storage depends on various factors such as crop or variety, initial seed quality, storage conditions, seed moisture content, insect pests, bacteria and fungi (Amruta *et al.,* 2015) [6]. Among these factors insect caused a significant contribution to the total loss, did not only damage the grain but also depreciate the weight and quality of stored grains (Rayhan, 2014) [39]. Insect damages include direct consumption of kernels, detritus of exuviate, webbing, and cadavers thereby makes the grain unfit for human consumption and also reduce quality and quantity. Insect infestation manipulate the storage environment resulted in development of hotspots which are congenial for the proliferation of storage fungi and other harmful micro flora (Rajashekar *et al.,* 2012) [37].

The attack caused by insect pests especially *Sitophilus zeamais*is, which is a cosmopolitan pest of grain posed a major biotic constraint to utilization of maize in the tropics and subtropics (Akob and Ewete, 2007) [5] and temperate regions of the world (Stoll,1986) [43]. Weight losses of 30-80% in storage caused by *S. zeamais* have been estimated for many areas (De-Lima, 1987) [14], around 5 – 10% in the temperate zone and 20 – 30% in the tropical zone (Rahman and Talukder, 2006; Rajendran and Sriranjini, 2008) [38]. However, such damage may reach up to 40% in countries where modern storage technologies have not been introduced and climate conditions are favorable (Shaaya *et al.,* 1997) [41]. Enobakhare and Law-Ogbomo, (2002a) [18] reported that damaged maize grains have reduced weight, poor marketability and low viability.

Plant-derived pesticides can be transferred into practical application in natural crop protection, which can help the small farmers. The use of botanical pesticides to protect plants from pests is very promising because they are environmental friendly, biodegradable, economic and are equally effective (Zettler and Cuperus 1990) [45], rather than problems of residual effects, pest resurgence, prevalent environmental and ecological hazards, insect pest resistance and economy of farmers associated with currently used synthetic pesticides (Elhag, 2000) [17]. Also, some plants have more than one chemical as an active principle responsible for their biological properties though for either one particular biological effect or diverse ecological effects (Saxena *et al*., 1989) [40]. Moreover if grains are to be stored for food purpose, pesticides sometimes prove to be poisonous or lethal. Plants having some insecticidal properties have been exploited to protect stored products from insect pests (Belmain and Stevenson, 2001) [11], including Azadirachtin compound known for its low toxicity against beneficial insects (Koona and Njoya, 2004) [28]. Some of the metabolites of plants are toxic such as pyrethrum, nicotine, rotenone etc., some are repellents, antifeedants like azadirachtin, rape seed extract and others, like *Acorus calamus* act as sterilants (Ignatowicz and Wesolowska, 2015) [23].

The objectives were to compare the efficacy and ascertain the optimum level of concentration of the botanicals at which control and reduction of storage losses could be achieved.

MATERIALS AND METHODS

Site of Study -The research was conducted at the Crop Protection Laboratory, Department of Crop and Soil Science, Faculty of Agriculture, University of Port Harcourt. The experiment was carried out under ambient temperature at 27 $\pm$ 3^0c and relative humidity 65 $\pm$ 5%, using thermometer and hygrometer.

Source of Maize Seed - Maize (DT.SYNII-W) used was collected from the International Institute of Tropical Agriculture (IITA), Ibadan, Oyo State, Nigeria.

Sources of plant materials - All three (Turmeric, Garlic and Curry leaf) plant materials were obtained from the National Root and Crop Research Institute (NRCRI), Umudike, Abia State.

Identification and sexing of insect - Examination of *Sitophilus zeamais* was done with a light microscope of high resolution to correctly identify adult maize weevil that was used for culture. Female was differentiated from male by morphological features

Insect Culture - Infested maize seeds were sieved and adult maize weevil obtained was introduced into the disinfested maize seeds and left for seven days to mate and lay eggs for the F_1 progeny to emerge in 10 litres containers covered with muslin cloth. Only newly emerged adult of *S. zeamais* was used for the experiment.

Seed treatment/Sterilization - Maize seeds were kept in a deep freezer (-4^OC) for seven days, and conditioned in the cooled incubator for another seven days to standardize the seeds moisture content.

Extraction of oil from plant materials. - Extraction of oil was carried out at the Chemistry Laboratory, Chemistry Department, Rivers State, University Port Harcourt. The extraction was done using sorhulet apparatus/extractor. Solvent used for both turmeric and curry leaf was ethanol, while Hexane was used for garlic. Each plant material (Turmeric, Garlic and Curry leaf) was weighed separately and made available for use. The gram of each plant material was one-third of 1ml of solvent used: $Turmeric - 69.71gram \times 3 = 209.13ml\ of\ ethanol\ used$; $Garlic - 121.385gram \times 3 = 364.155ml\ of\ haxane\ used$ and $Curry\ leaf - 58.52gram \times 3 = 175.56ml\ of\ ethanol\ used$

The gram of each plant material was put into a thine-boll. The solvent was measured into a round bottom flask. And the extraction was done under the following temperature viz turmeric was about $20\ \&\ 30℃ (68\ \&\ 86°F)$; garlic was about $32 - 50°F$ and for curry leaf, it was about $80 - 84°F$. The three extractions were not time dependent and the extracted oil of each plant material was kept in room temperature to evaporate

Bioassay – 20 grams of treated maize seeds were infested with 10 pairs of adult weevils in each plastic container. The seeds were mixed with the oil of plant material (Turmeric, Garlic, Curry leaf) separately in each plastic container. Oil of the plant materials were applied at different concentration of 0.25ml, 0.50ml and1.00ml respectively. Powder was also applied to the treated maize seed at 0.25g, 0.50g and 1.00g. However, the control containing infested maize seeds was left untreated. Each treatment was replicated four times and laid out in 3×3 factorial arrangement in a completely randomized design. The number of dead bruchids was counted in each container, 90 days after storage to estimate adult mortality. Data on percentage adult bruchid mortality was corrected using Abbott's (1925) formula.

$$Pt = \frac{(P_0 - P_c)}{100 - P_c} \times 100$$

Where; P_T = Corrected mortality (%); P_O = Observed mortality (%); P_c = Control mortality (%)

Data collected also included number of exit holes, seed damage, undamaged seed and seed weight loss.

Data collected included Adult weevil mortality, Exit holes, % seed damage, Undamaged seed, %Weight loss

% Weight Loss - Loss of grain imputed or caused by *S. zeamais* activity was measured using the following method: % weight loss = $\frac{X-Y}{X}\ x\ 100$

WhereX = Initial weight sample before infestation; Y = Final weight sample after infestation

% Seed Damage- Seed damage of the varieties of beans was obtained using the following method:% seed damage = $\frac{B-D}{B}\ x\ 100$

Where B = Number of seed before infestation; D = Number of damage/ unbroken seed after infestation.

% Undamaged Seed -Undamaged seed of the varieties of beans was obtained using the following method: % undamaged seed = $\frac{B-U}{B}\ x\ 100$

Where B = Number of seed before infestation; U = Number of damage/ unbroken seed before infestation.

RESULTS

Table 1 presents the results of the bioactivity and different concentrations of curry, garlic and turmeric products (oil and powder) against *Sitophilus zeamais*. Higher concentration of powdered and oil of curry, garlic and turmeric tested for the trial gave better protection against *Sitophilus zeamais*. The curry, turmeric and garlic (powder and oil) caused mortality of the weevil after three months storage. Thus, curry plant parts tested recorded the highest (82.50%), followed by turmeric (80.50% & 81.00%) and garlic (72.00% & 65.25%) as maize seed protectants at 0.50% and 1.00% concentrations. However, the plant parts tested recorded least values at 0.25% though higher than untreated (control) (Table 1&2). All plant product treatments were significantly different when compared with the control (P < 0.005). However punctured maize seed is a symptom of damage, an exit hole that served as emergent holes for the progeny of the weevil. Thus makes the seed unattractive and reduces market values. The untreated recorded the highest exit holes (ranges between 46.70 – 48.00%) compared with the treated maize seeds. Curry and turmeric (oil and powder) had lower mean number punctured grain than the garlic products, though there was only marginal difference. The curry plant parts had the least mean number of exit holes (11.00, 12.25), closely followed by turmeric (12.75, 12.75) thus, garlic recorded moderate high exit holes (15.50, 15.50) at higher concentrations of 0.50% and 1.00% (Table 1&2). Hence, Curry leaf (oil and powder) maintained the consistency as the better seed protectant. Consequently, maize seed treated with curry at 0.25%, 0.50% and 1.00% concentrations recorded little or no damage by adult weevils. Also, turmeric plant parts were more effective than garlic in the reduction of adult weevil development. Consequently, curry (oil and powder) recorded lowest percent seed damage compared with others and untreated maize seeds (control). The control however had the least. Control however suffered devastating attack because it was not protected and had the range values of (65.50% -71.30%) and (80.50 -81.75). Moreover, all the plant parts tested significantly (P<0.05) reduced the development of maize weevils compared with control. This is responsible for high percent undamaged seeds recorded by curry (78.00%, 89.00%) and turmeric (73.25%, 79.25%) at highest dose/ concentration. Garlic product equally recorded high undamaged seeds (71.50% & 69.00%) (Table 1&2). The oil and powder of plant parts tested had an appreciable reduction in percent weight loss. Also, all the tested plant parts were significantly different from control (P < 0.05) in causing adult weevil mortality. Grains treated with curry, turmeric and garlic both oil and powder gave appreciable reduction in percent weight loss (1.18, 1.62 and 2.80) (0.75, 1.75 and 2.50) in these order as compared with control (Table 1&2).

Table 3 (i&ii) showed that curry and turmeric oil recorded highest adult weevil mortality (58.38%, 57.00%), while garlic powder had the least (45.00%). Turmeric however recorded the least exit hole (13.56), whereas there was only marginal difference in exit holes by curry oil (20.38) and garlic powder (24.19). Consequently, garlic oil and powder recorded the highest percent seed damage (41.88% &42.75%), but turmeric of similar products had the least (33.25% & 36.64%). Similarly, this influenced the percent undamaged seeds recorded by garlic oil and powder having 58.13% and 57.25% whereas, curry oil recorded 66.75% against 64.49% by turmeric powder. There was only marginal differences in percent seed weight loss by the plant product treatments except garlic oil that is a little high (4.28%) Table 3(i&ii).

Table 4 showed that there was significant ($P < 0.01$) positive correlation between adult mortality (0.381**) and exit holes in powder treated maize seeds. Also, there was significant positive correlation between the seed weight loss (0.0509**) and seed damage, but significant negative correlation with undamaged seeds (-0.0643**). This means activity of survived insect dependent and determined number of maize seed punctured (i.e. exit holes dependent on insect survival). Therefore, increase in the percent seed damage determined undamaged seed recovered from the trial. Likewise in oil treated maize seeds, there was significant ($P < 0.01$) positive correlation between adult mortality (0.680**) and exit holes and seed weight loss (0.491**). Also, significant positive correlation existed between adult mortality seed damage (0.528**), undamaged seed (0.810**) and seed weight loss (0.529**) in oil treated seed maize (Table 4).

Curry and turmeric recorded the superior performance irrespective of products tested throughout the trial. Curry however had a marginal edge over the turmeric. However, garlic product was moderate as a protectant. Though, all plant product treatments were significantly recorded high values when compared with the untreated seeds (control). Therefore, the plant product treatments were dosage-dependent as they were more effective at higher concentration than at lower concentration.

Table 1: Interaction effect of plant powder at different level against *Sitophilus zeamais*

Protectant (powder)	Dosage (g) (w/w)	Percent Adult Mortality	Mean number of exit hole	Percent seed damage	Percent undamaged seed	Percent seed weight loss
Curry	0.00	0.00^{d}	46.75^{a}	71.30^{a}	28.70^{c}	4.25^{ab}
	0.25	55.00^{c}	$14.50b^{c}$	35.75^{bc}	64.25^{a}	1.38^{c}
	0.50	75.00^{b}	12.25^{c}	29.75^{c}	70.25^{a}	1.25^{c}
	1.00	82.50^{a}	11.00^{c}	21.75^{c}	78.25^{a}	1.18^{c}
Garlic	0.00	0.00^{d}	47.75^{a}	65.50^{a}	34.50^{c}	4.50^{ab}
	0.25	52.50^{c}	17.50^{bc}	43.00^{b}	57.00^{bc}	2.75^{bc}
	0.50	62.50^{bc}	16.00^{b}	31.50^{c}	68.50^{a}	2.12^{c}
	1.00	65.25^{bc}	14.50^{b}	31.00^{c}	69.00^{a}	2.00^{bc}
Turmeric	0.00	0.00^{d}	48.00^{a}	66.50^{a}	33.50^{c}	7.00^{a}
	0.25	60.00^{bc}	12.50^{c}	38.50^{bc}	61.50^{bc}	1.88^{c}
	0.50	72.50^{b}	12.00^{c}	30.75^{c}	69.25^{a}	2.00^{bc}
	1.00	81.00^{a}	11.75^{c}	26.75^{c}	73.25^{a}	1.62^{c}

Means are separated by Tukey's Honest Significant Difference Test at 5%.

Means followed by the same letter in the same column are not significantly different from one another

Table 2: Interaction effect of plant oil at different concentration against *Sitophilus zeamais*

Protectant (oil)	Concentration (ml) (w/v)	Percent Adult Mortality	Mean of exit hole	Percent seed damage	Percent undamaged seed	Percent seed weight loss
Curry	0.00	0.00[d]	40.75[a]	81.75[a]	18.25[c]	8.37[a]
	0.25	76.00[ab]	15.25[c]	22.25[c]	77.75[a]	2.00[c]
	0.50	75.00[ab]	13.25[c]	18.00[d]	82.00[a]	1.00[d]
	1.00	82.50[a]	12.25[b]	11.00[d]	89.00[a]	0.75[d]
Garlic	0.00	0.00[d]	44.75[a]	80.50[a]	19.50[c]	8.87[a]
	0.25	61.00[c]	19.25[b]	34.00[b]	66.00[b]	3.01[b]
	0.50	71.50[b]	17.25[b]	24.50[c]	75.50[a]	2.75[b]
	1.00	72.00[b]	15.50[b]	28.50b[c]	71.50[b]	2.50[b]
Turmeric	0.00	0.00[d]	49.75[a]	81.50[a]	18.50[c]	9.87[a]
	0.25	75.00[ab]	17.75[c]	23.50[c]	76.50[a]	2.25[c]
	0.50	72.50[b]	15.00[b]	16.30[d]	83.70[a]	1.00[d]
	1.00	80.50[a]	12.75[b]	20.75[c]	79.25[a]	1.75[d]

Means are separated by Tukey's Honest Significant Difference Test at 5%. Means followed by the same letter in the same column are not significantly different from one another

Table 3 (i): Effect of protectant on damage caused by *Sitophilus zeamais*

Protectant	Form	Percent Adult mortality	Mean of number of seed exit holes
Curry	Powder	53.00[b]	21.00[b]
Garlic		45.00[d]	23.94[a]
Turmeric		53.38[b]	13.56[c]
Curry	Oil	58.38[a]	20.38[b]
Garlic		51.13[c]	24.19[a]
Turmeric		57.00[a]	23.81[a]

Means are separated by Tukey's Honest Significant Difference Test at 5%. Means followed by the same letter in the same column are not significantly different from one another

Table 3 (ii): Effect of protectant on damage caused by *Sitophilus zeamais*

Protectant	Form	Percent Seed damage	Percent undamaged seed	Percent Seed weight loss
Curry	Powder	36.64[b]	60.36[b]	2.02[c]
Garlic		42.75[a]	57.25[c]	2.84[bc]
Turmeric		40.63[a]	59.38[b]	3.13[b]
Curry	Oil	33.25[c]	66.75[a]	3.03[b]
Garlic		41.88[a]	58.13[c]	4.28[a]
Turmeric		35.51[b]	64.49[a]	3.72[a]

Means are separated by Tukey's Honest Significant Difference Test at 5%. Means followed by the same letter in the same column are not significantly different from one another

Table 4: Correlation coefficient of curry, garlic and turmeric (powder & oil) on damage and biological parameters of *Sitophilus zeamais*

Parameters	Curry, garlic and turmeric powder		Curry, garlic and turmeric oil	
	Adult mortality	Seed weight loss	Adult mortality	Seed weight loss
Exit holes	0.381**	0.033	0.680**	0.491**
Seed damage	-0.226	0.0509**	0.528**	0.278
Undamaged seed	0.027	-0.0643**	0.810**	0.529**

**. Correlation is significant at the 0.01 level (2-tailed).

DISCUSSION

Insecticidal plant extracts prepared from the locally available material, degrade rapidly, have broad spectrum action and could be a better option for management of insect pests (Azad *et al.,* 2013) [9]. Plants having some insecticidal properties have been exploited since long past to protect stored products from insect pests (Belmain and Stevenson, 2001) [11]. From this study, the tested plant parts of high concentration of powdered and oil gave better protection against *Sitophilus zeamais*. Therefore, curry, turmeric and garlic (powder and oil) caused mortality of the weevil after three months storage. However, there was interaction effect due to direction of response and amount of response between plant parts and different concentrations tested. The highest mortality was recorded by the curry plant products on treated maize seeds. This agreed with the finding that curry plant is an essential oil crop that possesses a range of biological activities such as insect repellant, nematicidal, anti-bacterial, antifungal and antioxidant activities (Simon *et al.,* 1990, Lee *et al.,* 2005) [42,30]. Klimankova *et. al.,* (2008) [27] however implicated compounds like 1, 8-cincole, methyl cinnamate, methyl chavicol and linalool as constituents responsible for the distinct aroma of basil plants. Turmeric and garlic oil are also effective in maize seed protectant at 0.50% and 1.00% concentrations better than 0.25%. This agreed with the finding that *Cassia sophera* leaf powder, when mixed with different commodities at 1% and 5% concentrations significantly reduced adult emergence of *S. zeamais, Callosobruchus maculatus* and *Rhyzopertha dominica* in laboratory experiments (Belmain *et al*., 2001) [12]. There is a general consensus that the active ingredients of fatty vegetable and rhizomatous plant oils are their fatty acid constituents such as turmerones and arturmerone, oleic, linolenic and arachidonic acids (Don-Pedro, 1990; Tripathi *et al.*, 2002) [15,44]. In the same vein, Tripathi *et al.*, (2002) [44] reported that turmerone and ar-turmerone are major constituents of *C. longa* rhizome oil and insecticidal constituents of leaf and root having 82.9% and 16.3% Monoterpenes respectively, which responsible for the lethal effects exhibited by turmeric plants. Similar work reported that neem product Azadirachtin causes 100% mortality to *Sitophilus oryzae* (Athanassiou *et al.,* 2005) [8]. However, garlic powder and oil tested are equally effective at the same concentrations of 0.50% and 1.00%. Garlic is reportedly effective against wide range of insects at different stages in their life cycle and aqueous or organic solvent extracts are being used in many countries as protectants of stored products (Fernando and Karunaratne, 2012) [16]. Similarly, Bouda *et al*., (2001) [13] reported that essential oil extracts of *Ageratum conyzoides, Lantana camara* and *Chromolaena odorata* were effective insecticide in the control of *S. zeamais*. Significantly higher adult weevil mortality was recorded on maize treated with 0.50% and 1.00% concentrations of both powder and oil compared to 0.25%. In a similar finding, Ahmed *et al*. (1999) [4] showed that after three days of release, 100% of the *C. chinensis* adults were found dead on neem oil-treated beans. Other researchers, Nukenine *et al.,* (2011) [32] reported a similar finding that neem based viz. Neem Azal and NSO (neem seed oil) had sufficient efficacy against *S. Zeamais* and could be employed as component of an integrated management. According to Amruta *et al*., (2015) [6], who reported that the quality of grains and seeds during storage depends on insect pests though one of the major contributing factors. However, punctured maize seed is a symptom of damage since it makes the seed unattractive and reduces market values. Thus exit hole served as emergent holes for the progeny of the weevil during eclosion. Maize seeds treated with plant parts had reduced number exit hole than the untreated seed (control) at different concentrations of 0.25%, 0.50% and 1.00%. This reduction could be attributed to low adult bruchid mortality in the untreated seed. This agrees with the similar findings reported by Kestenliolz *et al*., (2007) that significantly lower damage was recorded in rice grains treated with *Cassia sophera* leaf powder at 1.00% and 5.00%. The quality of grains and seeds during storage depends on insect pests but did not only damage the grain, also depreciate the weight and quality of stored grains (Rayhan, 2014) [39]. Consequently, the tested plant parts significantly reduced the development of *S. zeamais* that could lead to the damage of maize seeds. Curry (oil and powder) recorded lowest percent seed damage compared with others. Control suffered devastating attack because it was not protected and had the highest values. This agrees with the similar finding of Aziza, (1988) [10] that damage was significantly lower in rice grains treated with sun-dried guava and *Eucalyptus* leaves against *S. oryzae* and *S. granaries* in the stores. Correspondingly, high percent undamaged maize seeds were recorded by the tested plant parts. The untreated maize seeds (control) however, had the least. This result is consistence with previous work by Adedire *et al*., (2011) [3] who reported that *S. zeamais* causes 20 to 90 % loss of unprotected maize seeds. This corroborates similar findings by Enobakhare and Law-Ogboma, (2002b) [19] who reported that damaged grains are not adequately viable for successful planting by farmers because it is impaired, nutritional value of the staple food is reduced; perforations and weight loss, also affect market value adversely. In terms of reduction of percent seed weight loss caused by adult weevils, all the plant parts tested had appreciable effects. This could be attributed to toxic insecticidal effect and certain nutritional inhibitors in the plants. It has been shown that the insecticidal property possessed by some essential oils is due to their monoterpenoid contents (Lale, 1987) [23].Consequently, Monoterpenes have been well reported to be active as fumigants, repellants or insecticides towards stored grain insects (Obeng-Ofori, and Reichmuth, 1997) [23]. Curry leaf oil and powder maintained the consistency as the better seed protectant. This is also in agreement with the findings that curry plant possesses a range of biological activities such as insect repellant, nematicidal, anti-bacterial, antifungal and antioxidant activities (Simon *et al.,* 1990, Lee *et al.,* 2005) [42,30], and however implicated 1, 8-cincole, methyl cinnamate, methyl chavicol and linalool as the constituents that responsible for the distinct aroma of basil plants (Klimankova *et. al.,2008)* [27]. Asawalam *et al.,* (2008) [7] reported that the curry oil was found to be moderately repellant to the maize weevil and had a significant reduction in the number of progeny derived from the maize weevil indicating the potential use of the plant in post-harvest control. In a similar finding, bioefficacy results from Lolage and Patil (1992) [31] showed that neem, karanj, castor, groundnut and mustard oils significantly reduced seed damage rate from *C. maculatus* infestation. Garlic possess a lethal property similar and as efficient as DDT and however effective against wide range of insects at different stages in their life cycle (eggs, larvae, adult) this includes ants, moths, beetles, termites, tick, etc. Paradoxically, it is not recommended for aphid control since it kills the natural enemies of aphids.

In this study, adult weevil mortality was significantly positive correlated with exit holes, percent seed damage and weight loss but negatively with undamaged powder treated seed. This implies that activity of survived insects dependent and determined number of maize seed punctured (exit holes) and by extension caused the seed damage. Several workers, Ghawana *et al.,* (2011) [22] confirmed that plant products possess several kinds of biological activity and exerted toxic effects by disrupting physiological process like feeding, post –embryonic development and increased mortality. This is attributed to toxic effect exerted by disrupting normally respiration activity of the weevil thus results in asphyxiation and subsequent death (Klimankova *et. al.,* *2008*) [27]. However, significant positive correlation existed between adult mortality, exit holes, seed damage, seed weight loss and undamaged oil treated seed. This is confirmed by the findings of Belmain *et al*., (2001) [11] who reported that when *Cassia sophera* leaf powder was mixed with different commodities at 1% and 5% concentrations significantly reduced adult emergence of *Sitophilus zeamais* and *Rhyzopertha dominica* in laboratory experiments. Thus different botanicals can be used effectively to treat grains (Obeng, 2010) [33] depending upon the locations as activity of botanicals varies across geographical locations (Kaushik *et al.,* 2007; Abdalla *et al.,* 2010) [2,25]; even with differences in storage durations and conditions. These results suggest that all the parts of the plants tested possess insecticidal properties but at varying degrees. All the plant product treatments were dosage-dependent as they were more effective at higher concentration than at lower concentration. This study however affords opportunity to know the substantial and specific concentration of curry and turmeric oil and powder to use for effective control. The plant parts tested are of plant origin and a cheap source of plant protection component which a farmer should deploy to prevent post harvest storage losses experienced on farms and stores.

CONCLUSION

The results showed that curry oil and turmeric powder at lower concentration (0.50%) could be used for efficient control of maize weevil

The most bioactive among the three tested oil was curry while turmeric powder was however promising

The tested plant oil is more effective though plant powder is equally effective

REFERENCES

[1]. Abbott, S.W. (1925). A method of computing the effectiveness of an insecticide. Journal of Economic Entomology 18: 265-267

[2]. Abdalla, A.S., Mohamed, E.E. and Abdin, E.M. 2010. Insecticidal activities of neem (*Azadirachta indica* A. Juss) seeds under laboratory and field conditions as affected by different storage durations. *Agric. Biol. J. Am.,* 5:1001–1008.

[3]. Adedire, C., Akinkurolere, R. and Ajayi,O. (2011) Susceptibility of some maize cultivars in Nigeria to infestation and damage by maize weevil, *Sitophilus zeamais* (Motsch.)(Coleoptera: Curculionidae), *Nigerian Journal of Entomology,* vol. 28, pp. 55-63.

[4]. Ahmed, K. S.,Itino, T. and Ichikawa, T. (1999). Effects of plant oils on oviposition preference and larvalsurvivorship of *Callosobruchus chinensis* (Coleoptera:Bruchidae) on azuki bean. Applied Entomology and Zoology, Vol., 34(4):547–550

[5]. Akob, C. A. and Ewete, F. K. (2007). The efficacy of ashes of four locally used plant materials against Sitophilus zeamais (Coleoptera: Curculionidae) in Cameroon. International Journal of Tropical Insec Science 27(1): 21-26

[6]. Amruta, N., Sarika, G., Umesha, Maruthi, J.B. and Basavaraju, G.V. 2015. Effect of botanicals and insecticides seed treatment and containers on seed longevity of black gram under natural ageing conditions. *J. App. Nat. Sci.,* 7 (1): 328 – 334.

[7]. Asawalam, E. F. , Emosaire, S. O. and Hassanali, A. (2008). Essential oil of Ocimum grattissimum (Labiatae) as Sitophilus zeamais (Coleoptera: Curculionidae) protectant African Journal of Biotechnology Vol. 7 (20) pp 3771-3776

[8]. Athanassiou, C.G., Kontodimas, D.C., Kavallieratos, N.G. and Anagnou-Veroniki, M. (2005). Insecticidal effect of NeemAzal against three stored-product beetle species on rye and oats. *J. Eco. Entom.,* 98:1499–1505.

[9]. Azad, A.K., Sardar, A., Yesmin, N., Rahman, M. and Islam, S. (2013). Eco-friendly pest control in cucumber (*Cucumis sativa* L.) field with botanical pesticides. *Nat. Reso.,* 4(5): 6p.

[10]. Aziza, S. (1988). Evaluation of some Myrtaceae plant leaves as protectants against the infestation by *Sitophilus oryzae* L. and *Sitophilus granaries* L. Journal of Insect Science Application 9 (4): 465-468'

[11]. Belmain, S., and Stevenson, P. 2001. Ethno-botanicals in Ghana: reviving and modernizing age old farmer practice. *Pest. Out,* 12:233–38.

[12]. Belmain, S. R., Neal, G. E., Ray, D. E. and Golob, P. (2001). Insecticidal and vertebrate toxicity associated with ethnobotanicals used as post-harvest protectants in Ghana. Food an Chemical Toxicology 39: 287-291

[13]. Bouda, H., Tapondjou, L. A., Fontem, D. A. and Gumedzoe, M. Y. D. (2001). Effect of essential oils from leaves of Ageratum conyzoides, Lantana camara and Chromolaena odorata on the mortality of Sitophilus zeamais (Coleoptera: Curculionidae). Journal of Stored Products Research, (37): 103-109'

[14]. De lima, C. P. F. (1987). Insect pest and post harvest problem in the tropics. Insec Science and its Application 8: 673-676

[15]. Don-pedro, K. N. (1990). Insecticidal activity of fatty acid constituents of fixed vegetable oils against Callosobruchus maculatus (F.) in cowpea. Pesticide Science 30: 295 -302

[16]. Fernando, H.S.D. and Karunaratne, M.M.S.C. (2012). Ethno-botanicals for storage insect pest management: Effect of powdered leaves of *Olax zeylanica* in suppressing infestations of rice weevil *Sitophilus oryzae* (L.) (Coleoptera: Curculionidae). *J. Trop. For. Environ.,* 2(1): 20-25.

[17]. Elhag, E.A. 2000. Deterrent effects of some botanical products on oviposition of the cowpea bruchid *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae). *Int. J. Pest Manag.,* 46(2): 109-113.

[18]. Enobakhare, D. A. and Law-Ogbomo, K. E. (2002a). Reduction of post-harvest loss caused by Sitophilus zeamais (Motsch) in three varieties of maize treated with plant products. Post-harvest Science. Vol. 1: 1-6

[19]. Enobakhare, D. A. and Law-Ogbomo, K. E. (2002b).Reduction of postharvest loss caused by *Sitophilus zeamais* (Motsch) in three varieties of maize treated with plant products, *Post Harvest Science,* vol. 1, pp. 1-6

[20]. FAO, 1992. Aquaculture production (1984 – 1990) FAO Fish. Circ. (815) Rev. 4: 206

[21]. Felix, M. P. (1997). The struggle of Latino/a University students: Routledge 29 West 35th Street, New York, NY 10001 244pp

[22]. Ghawana, S., Paul, A., Kumar, A., Singh, H., Bhardway, P. K., Rani, A., Singh, R.S., Raizada, J., Singh, K. and kumar, S. (2011). An RNA isolation system for plant tissues in secondary metabolites. BMC Research Notes 4, Article Number: 85

[23]. Ignatowicz, S. and Wesolowska, B. (2015). Potential of common herbs as grain protectants: repellent effect of herb extracts on the granary weevil, *Sitophilus granarius* L. Proceedings of 6th International Working Conference on Stored-products Protection, 2: 790-794.

[24]. Iken, J. E. and Amusa, N. A. (2004). Review: Maize research and production in Nigeria. African Journal of Biotechnology Vol. 3(6): 302 – 307

[25]. Kaushik, N., Singh, B.G., Tomar, U.K., Naik, S.N., Satya, V., Bisla, S.S., Sharma, K.K., Banerjee, S.K. and Thakkar. P. (2007). Regional and habitat variability in azadirachtin content of Indian neem (*Azadirachta indica* A. Jusieu). *Curr. Sci.,* 92:1400–1406.

[26]. Kestenholz, C., Stevenson, P. C., Belmain, S. R. (2007). Comparative effects of field and laboratory evaluations of the ethnobotanical *Cassia sophera* L. (Leguminosae) for bioactivity against the storage pests *Callosobruchus maculatus* F. (Coleoptera: Bruchidae) and *Sitophilus oryzae* L. (Coleoptera: Curculoinidae). Journal of Stored Products Research 43: 79-86.

[27]. Klimankova, E., Holaslova, K., Hajslova, J., Cajka, T., Poustka, J. and Koudela, M. (2008). Journal of Stored Products Research. Vol. 107 (1): 464-472

[28]. Koona, P. and Njoya, J. (2004). Effectiveness of soybean oil and powder from leaves of Lantana camara L. (Verbenaceae) as protectants of stored maize against infestation by Sitophilus zeamais Motsch. (Coleoptera: Curculionidae). Pakistan Journal of Biological Sciences, 7 (2004) pp. 2125 – 2129.

[29]. Lale, N. E. S. (1987). Insecticidal activity of plant essential oils on Callosobruchus maculatus (F.) (Coleoptera: Bruchidae), Ph. D Thesis University of New Castle Upon Tyne, UK. 150pp

[30]. Lee, B. H., Anis, P. C., Tumalii, F. and Lee, S. E. (2004). Fumigant toxicity of Eucalyptus blakelyi and Melaeuca fulgens essential oils and 1,8- cineole against different development stages of the rice weevil, Sitophilus oryzae. Phytoparasitica, 32 (2004), pp498-506.

[31]. Lolage, G. R. and Patil, R. B.(1992). Comparative efficacy of plant oils against *Callosobruchus maculatus* F. on pigeon pea.Journal of Maharashtra Agricultural Universities1992; 16(3):327–329

[32]. Nukenine, E.N., Tofel, H.K. and Adler, C. 2011. Comparative efficacy of Neem Azal and local botanicals derived from *Azadirachta indica* and *Plectranthus glandulosus* against *Sitophilus zeamais* on maize. *J. Pest Sci.,* 84: 479–486.

[33]. Obeng-Ofori, D. 2010. Residual insecticides, inert dusts and botanicals for the protection of durable stored products against pest infestation in developing countries. 10th International Working Conference on Stored Product Protection, Section: Residual Insecticides – Synthetic and Botanical: 474-478.

[34]. Obeng-Ofori, D. and Reichmuth, C. H. (1997). Bioactivity of eugenol, a major component of essential oil of Ocimum suave (Wild.) against four species of stored product, Coleoptera. International Journal of Pest Management 43: 89-94

[35]. Pingali, P. L. (2000).CIMMYT 1999 – 2000 World Maize Facts and Trends. Meeting World Maize Needs: Technological opportunities and priorities for the public sector. Mexico, D. F. CIMMYT.

[36]. Rahman, A. and Talukder, F. A. (2006). Bioefficacy of some plant derivatives that protect grain against the pulse beetle, *Callosobruchus maculatus*. Journal of Insect Science Vol. 6(1) 3 https//doi.org 10.1673/1536-2442(2006) 6[1:BOSPDT] 20C0;2.

[37]. Rajashekar, Y., Bakthavatsalam, N. and Shivanandappa, T. (2012). Botanicals as grain protectants. *Psyche: A J. Ento,* 13 Pp.

[38]. Rajendran, S. and Sriranjini, V. (2008). Plant products as fumigants for stored product insect control. Journal of Stored Product Research. Vol. 44 (2) pp126-135

[39]. Rayhan, M.Z., Das, S., Sarka,r R., Adhikary, S.K., Tania, S.N., Islam, M.M. and Rabbani, M.G. (2014). Bioefficacy of neem, mahogoni and their mixture to protect seed damage and seed weight loss by rice weevil in storage. *J. Biod. Env. Sci.,* 5(1): 582-589.

[40]. Saxena, R. C., Jilani, G. and Kareem, A. A. (1989). Effects of Neem on stored grain insects, Jacobson, M. ed. (1988). Focus on Phytochemical Pesticides. Vol. 1. The Neem Tree. Pp97 – 112 Boca Raton, Florida, USA, CRC Press, Inc

[41]. Shaaya, E., K ostukovski, M., Eilberg, J. and Sukprakaran, C. (1997). Plant oils as fumigants and contact insecticides for the control of stored-product insects. Journal of Stored Product Research 33 (1): 7-15.

[42]. Simon, J. E., Quin, J., and Murray, R. G. (1990). Basil: a source of essential oils. In: J. Jarrick and J. E. Simons (eds). Advances in new crops. Timber Press, Portland ,U.K. pp 484-489

[43]. Stoll, G. (1986). Principles of preventive crop protection based on local farm resources in the tropics and subtropics, 2nd Edition. Natural Crop Protection III, Langen Margraf.

[44]. Tripathi, A. K., Prajapati, V., Verma, N., Bahl, J. R., Bansal, R. P. Khanuja, S. P. S. and Kumar, S. (2002). Bioativities of the leaf essential oil of Curcuma longa (Var. Ch-66) on three species of stored product beetles (Coleoptera), Journal of Economic Entomology, Vol. 95 (1) pp 183-189.

[45]. Zettler, J.L. and Cuperus, G.W. (1990). Pesticide resistance in *Tribolium castaneum* (Coleoptera: Tenebrionidae) and *Rhizopertha dominica* (Coleoptera: Bostrichidae) in wheat. *J. Econ. Entom.,* 83: 1677–1681.