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Assesement of Efficacy of Different Technologies for the Control of Cowpea Beetle (*Callosobruchus Maculatus)* (F)) (Coleoptera: Bruchidae) in Stored Cowpea

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Abstract

This study explored the effectiveness of different storage strategies—including rice husk ash, lemon grass leaf powder, triple-layer bags, and steam treatment—in suppressing infestations of Callosobruchus maculatus in stored cowpea. The research was conducted under ambient lab conditions at Bayero University, Kano. Lemon grass was procured from Yan Kaba market and processed into powder, while rice husk ash and triple-layer bags were sourced from Dawanau market. The cowpea beetles were collected from local storage facilities and were identified using taxonomic keys before being cultured in the lab. Different levels of concentration, material size, and treatment duration were tested using 20g of cowpea per sample. Specifically, concentrations of 5.0%, 10.0%, and 15.0% w/w; thicknesses of 0.05, 0.06, and 0.07 mm; and heating times of 10, 15, and 20 minutes were employed. Control groups were included. Each treatment was replicated three times using a completely randomized design. Three adult pairs of newly emerged C. maculatus were introduced to each setup. Variables measured included insect mortality, number of eggs laid, egg viability, emergence of F1 adults, and seed weight loss. Findings showed that rice husk ash at 3g and triple-layer bags of 0.07mm were the most effective treatments, achieving 100% mortality of C. maculatus within 96 hours. These methods also significantly reduced the number of eggs laid, egg viability, adult emergence, and weight loss in cowpea seeds. The results underscore the importance of these storage methods in preserving cowpea quality.

Keywords: Cowpea seeds, *C. maculatus*. Lemon grass leaf, Rice husk ash, Tripple bags Hydrothermal Steam

1. INTRODUCTION

Cowpea (Vigna unguiculata L. Walp.) is one of the earliest domesticated legumes and serves as a major protein source, especially for rural and urban populations in Nigeria. Nigeria is Africa's leading producer of cowpea, which is considered the most economically important native legume (Langyntuo et al., 2003). In 2010 alone, global production reached about 5.5 million tons from 14.5 million hectares (Musa & Adeboye, 2017). The crop is essential not only for food but also for income generation for smallholder farmers in sub-Saharan Africa. Its nutritional benefits include high protein content, essential minerals, and amino acids. Despite these advantages, cowpea production faces challenges such as pests, diseases, weeds, and drought (Gungula & Garjila, 2005). A major issue is post-harvest damage from beetles, particularly *Callosobruchus maculatus*, which can cause losses of 20-50% during storage. Annually, about 30,000 tons of cowpea—worth over $30 million—are lost due to this pest (Onuh & Onyenekwe, 2008). Though insecticides can control the beetle effectively (Dzemo et al., 2010), their high cost and potential health risks make them unsuitable for small-scale farmers. Furthermore, improper pesticide use can lead to resistance and residue accumulation. Hence, safer and more affordable alternatives, such as natural powders and improved storage methods, are essential.

2. MATERIALS AND METHOD

Experimental Site

The experiments were carried out in the Postgraduate Laboratory and the Central Laboratory Complex of the Department of Biological Sciences, Bayero University, Kano, located between latitudes 11°59′00.7”N and 11°58′49.2”N and longitudes 8°28′35.3”E to 8°29′00.8”E. The ambient lab conditions maintained were approximately 27 ± 3°C and 50–70% relative humidity.

Cowpea Seed Preparation

Healthy cowpea seeds (*Vigna unguiculata*, IT93K-452-1) were bought from Dawanau Market and authenticated at Bayero University's Plant Biology Department.

Treatment Materials and Experimental Design

Rice husk was burned into ash, cooled, and stored in airtight containers. Various concentrations (1g, 2g, 3g) were mixed with 20g cowpea in sterilized petri dishes. Each dish received three pairs of adult C. maculatus. Muslin cloth was used to cover dishes for ventilation. The experiment was replicated three times in a completely randomized design. Negative controls were also established. Observations were made daily for beetle mortality, egg laying, egg viability, F1 emergence, and seed weight loss. Lemon grass leaf powder was also tested in petri dishes. Various concentrations (1g, 2g, 3g) were mixed with 20g cowpea in sterilized petri dishes. Each dish received three pairs of adult C. maculatus. Muslin cloth was used to cover dishes for ventilation. The experiment was replicated three times in a completely randomized design. Negative controls were also established. Observations were made daily for beetle mortality, egg laying, egg viability, F1 emergence, and seed weight loss. Collected and disinfested cowpea seeds were allowed to equilibrate at room temperature before steaming. Twenty (20g) of cowpea seeds were separately placed on different metal trays. Each metal tray was separately heated, using electric steamer, for 10, 15 and 20minute, and each treatment replicated three times. The heated cowpea seeds were then separately transferred into plastic containers. Three (3) pairs of newly emerged *C. maculatus* adults were separately inoculated into these containers and were arranged in completely randomized design in the laboratory. Mortality of insect, number of eggs laid, viable eggs count and subsequent F1adult emergence were separately monitored in all the treatments. Triple layer Purdue Improved Crop Storage (PICS) bags with three different thicknesses (0.05, 0.06 and 0.07mm) were used. Twenty (20g) of disinfested cowpea seeds were separately put into these bags, and Three (3) pairs of newly emerged *C maculatus* were released into each of the bags. Each treatment was replicated three (3) times and arranged in complete randomized design. Mortality, number of egg laid, viable eggs, F1 adult emergence and weight loss of the seeds were recorded. The initial weight of cowpea (20g) were measured and the final weight of cowpea after F1 adult emergence of *C. maculatus* were also measured using weighting balance. Weight loss was then calculated using the following formula. Weight loss= initial weight –final weight /initial x100

Statistical Analysis

Data were analyzed using SPSS version 20. One-way ANOVA was conducted, and treatment means were compared using Least Significant Differences (LSD) at a 5% significance level.

Table 1: Mortality of *Callosobruchus maculatus* reared under different storage technologies

Treatment	Amount/Time /Size	Weight of cowpea (g)	Number of insects used	Mortality percentage			
				24 Hours	48 Hours	72 Hours	96 Hours
Rice husk ash	1g	20	6	0.00[a]	5.55[a]	22.22[b]	44.44[b]
	2g	20	6	22.22[b]	50.00[b]	88.88[c]	100.0[d]
	3g	20	6	33.33[c]	77.77[c]	100.0[d]	100.0[d]
Lemon grass	1g	20	6	0.00[a]	0.00[a]	11.11[a]	27.7[b]
	2g	20	6	5.55[a]	11.11[a]	36.88[b]	61.11[c]
	3g	20	6	16.11[b]	36.88[b]	55.55[b]	72.22[c]
Hydrothermal	10 min	20	6	0.00[a]	0.00a	5.55[a]	22.22[b]
	15 min	20	6	5.55[a]	5.55[a]	22.22[b]	22.22[b]
	20 min	20	6	5.55[a]	11.11[a]	33.33[b]	50.00[b]
Tripple bagging	0.05 mm	20	6	11.11[b]	38.88[b]	66.66[c]	88.88[c]
	0.06 mm	20	6	27.77[c]	55.55[b]	83.33[c]	100.0[d]
	0.07 mm	20	6	38.88[c]	83.33[c]	94.44[d]	100.0[d]
Control (-ve)		20	6	0.00[a]	0.00[a]	0.00[a]	0.00[a]

Mean with the same letter within a column are not significantly different from each other by ANOVA and turkey test ($p< 0.05$).

Table 2: Oviposition and egg viability of *C.maculatus* in cowpea seed treated with different storage technologies

Treatment	Amount/Time /Size	Weight of Cowpea Seed(g)	Number of Insect, Used	Mean number of egg laid, (± S.E)	Mean number of viable eggs (± S.E)	Viable egg (%)
Rice husk ash	1g	20	6	40.33±2.02[d]	33.33±1.45[c]	82.64
	2 g	20	6	31.66±2.02[c]	29.33±0.66[c]	92.64
	3 g	20	6	16.33±0.88[b]	14.66±1.45[b]	89.77
Lemon Grass	1 g	20	6	41.33±0.66[d]	35.00±2.33[c]	84.68
	2 g	20	6	37.33±1.20[d]	32.00±1.15[c]	85.72
	3 g	20	6	28.33±1.20[c]	20.66±1.20[b]	70.59
Hydrothermal	10min	20	6	47.00±2.31[e]	42.33±2.12[d]	90.06
	15min	20	6	40.33±2.02[d]	32.66±1.31[c]	80.98
	20min	20	6	36.00±1.43[d]	30.00±2.01[c]	83.33
Triple bagging	0.05mm	20	6	13.66±0.88[b]	9.33±0.88[a]	68.30
	0.06mm	20	6	8.33±0.88[a]	5.33±0.88[a]	63.98
	0.07mm	20	6	5.33±0.88[a]	3.00±0.57[a]	56.28
Control(-ve)		20	6	0.00±0.00[a]	102±0.53[e]	0.00

The same letter within a column is not significantly different from each other by ANOVA and turkey test ($p < 0.05$).

Table 3: Emergence of F1 adult *C.maculatus* from cowpea seed treated with different storage technologies

Treatment	Amount/Time /Size	Weight of Cowpea Seed	Number of Insect used	Mean number of viable eggs (± S.E)	Mean no. of Adult Emergence (± S.E)	F1 adult emergence (%)
Rice husk ash	1	20	6	33.33±1.45^{c}	26.33±2.33^{b}	65.00
	2	20	6	29.33±0.66^{c}	21.21±2.65^{b}	66.32
	3	20	6	14.66±1.45^{b}	11.2±.0.88^{a}	67.33
Lemon Grass	1	20	6	35.00±2.33^{c}	27.66±1.42^{b}	66.92
	2	20	6	32.00±1.15^{c}	21.66±1.33^{b}	58.02
	3	20	6	20.66±1.20^{c}	15.33±1.76^{a}	54.11
Hydrothermals.	10min	20	6	42.33±2.12^{d}	35.33±1.23^{c}	75.17
	15min	20	6	32.66±1.31^{c}	27.33±1.41^{b}	67.76
	20min	20	6	30.00±2.01^{c}	22.33±1.31^{b}	62.02
Triple bagging	0.05mm	20	6	9.33±0.88^{a}	5.33±0.33^{a}	72.63
	0.06mm	20	6	5.33±0.88^{a}	3.66±0.88^{a}	75.04
	0.07mm	20	6	3.00±0.57^{a}	1.33±0.88^{a}	49.14
Control(-ve)		20	6	102±0.53^{b}	92±0.53^{b}	90.19

The same letter within a column are not significantly different from each other by ANOVA and turkey test ($p < 0.05$).

Table 4: Loss of weight of cowpea seeds infested with *C.maculatus* which were treated with different storage technologies

Treatment	Amount/Time /Size	number of insects used	initial weight of cowpea seeds	final weight of cowpea seeds	loss of weight	Weight loss (%)
Rice husk ash	1	6	20	16.52±0.24^{b}	3.42	17.0
	2	6	20	17.74±0.23^{c}	2.26	11.3
	3	6	20	18.83±0.10^{d}	1.17	5.9
Lemon Grass	1	6	20	16.58±0.68^{b}	3.48	17.2
	2	6	20	17.84±0.13^{c}	2.17	10.8
	3	6	20	18.94±0.21^{d}	1.06	5.3
Hydrothermal	10min	6	20	15.628±0.21^{b}	4.38	21.9
	15min	6	20	16.08±0.13^{c}	3.92	19.6
	20min	6	20	17.03±0.07^{c}	2.97	14.85
Triple bagging	0.05mm	6	20	18.10±0.16^{d}	1.90	9.5
	0.06mm	6	20	18.50±0.26^{d}	1.50	7.5
	0.07mm	6	20	19.36±0.08^{d}	0.64	3.2
control(-ve)		6	20	11.6±0.70^{a}	8.4	41

Mean ± S.E with the same letter within a column are not significantly different from each other by ANOVA and turkey test($p < 0.05$).

3. RESULTS AND DISCUSSION

The study found that rice husk ash and triple-layer bags at their highest application levels (3g and 0.07mm, respectively) caused complete mortality (100%) of *C. maculatus* within 96 hours. This aligns with earlier studies (e.g., IIeke, 2012; Suleiman et al., 2011) showing botanical powders can be lethal to storage pests. Egg laying and viability were significantly reduced in seeds treated with these methods. For example, the 0.07mm triple bag resulted in only 5.33 eggs laid and 3 viable eggs, compared to over 100 in untreated samples. These findings are consistent with those of Umar (2008) and Othira et al. (2009), who noted oviposition deterrent effects from botanical powders. Emergence of F1 adults was also lowest in the triple-layer bag treatment (1.33 adults) and rice husk ash (11.2 adults), suggesting these methods are effective in disrupting insect development. The data correlate with those of IIeke & Oni (2011) and Ibrahim & Aliyu (2014), who observed inhibition of progeny emergence with similar treatments. Seed weight loss followed a similar trend, with the least damage in triple-layer bags (0.64g) and lemon grass (1.06g), far below the control group's 8.4g. This finding aligns with Parwada et al. (2012) and Simbarashe et al. (2013), who showed that botanical powders reduce grain damage.

4. CONCLUSION

The results showed variations in effectiveness to the various storage technologies of control of *C. maculatus*. Highest percentage mortality of adult *C. maculatus* (100%) were recorded on seed treated with rice husk ash and tripple bags at high treatment level of 3g and in 0.07mm, respectively, at 96hours of treatment. While the lowest mortality were recorded on seed treated with lemon grass leaf and hydrothermal steam at highest treatment level of 3g and 20minutes which recorded 72.22 and 50.00, respectively at 96hour of treatment. Tripple layer hermetic bags at 0.07mm thickness is the most effective in preventing oviposition and viability of *C.Maculatus* eggs which recorded 5.33±0.88 number of eggs laid and 3.00±0.57 number of viable eggs when compared with other treatments. Adult emergence were significantly ($P<0.05$) reduced in tripple layer bags at 0.07mm wall thickness 1.3±0.88 and at concentrations of 3g of rice husk ash 11.2±0.88 respectively, Maximum reductions of seed weight loss were recorded in tripple bags 0.64±0.08 at 0.07mm thickness and Lemon grass leaf 1.06±0.10 at concentrations of 3g respectively.

REFERENCES

1. Abdullahi, A. Usman, I. S. Girei, A. A. and Isma'il, G. (2016).Examination of Indigenous Storage Methods of Cowpea (*Vigna unguiculata*) in Mubi South Local Government Area, Adamawa State, Nigeria. *Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development 16(3): 16.*
2. Abdullahi, N (2011). Studies on the susceptibility of leaf extract of *Balanitesa egypitaca* on the oviposition and survival of immature stage of *C. maculatus*(F) on treated cowpea seed, *Bayero Jounal of Pure and Applied Science ,*4(1): 40-43
3. Adedire, C.O (2001). Biology, Ecology and control of insect pest of Stored cereal grains .in; ofuya TI, Lale NES, editors, pest of stored cereal and pulses in Nigeria: Biology, ecology and control. Dave Collin publications.
4. Akinneye J O ,Ogungbite OC.(2013). Insecticidal activities of some medicinal plants against *C.maculatus*(Coleoptera: Curculionidae) and *S.zeamais*(Motschulsky) on stored grains Arch *Phytopathology. Plant protection.*46(10): 1206-1213.
5. Appiah, F., Asibuo, J. Y. and Kumah, P. (2011).Physicochemical and functional properties of bean flours of three cowpea (*Vigna unguiculata* L. Walp) varieties in Ghana. *African Journal of Food Science* [online] Vol. 5(2), pp. 100 – 104.
6. Asmanizar, Djamin, A. and Idris, A.B.(2008). Effect of selected plant extract on mortality of *Callosobruchus maculatus*(F). (coleopteran; Bruchadae), pest of stored rice grains . *Malaysian Applied Biology,* 37(2); 41-46.
7. Baidoo, P. K. Mochiah, M. B. and Owusu-Akyaw, M. (2010). The effect of time of harvest on the damage caused by the cowpea weevil *Callosobruchusmaculatus*(Fab.) (Coleoptera: Bruchidae). *Journal of Stored Products and Postharvest Research 1(3): 24 - 28http://www.academicjournals.org/jsppr. (Accessed on:13/05/2017)*

8. Bartosik, R., Rodríguez, J., Cardoso, L., Malinarich, H., (2008). Storage of corn, wheat soybean and sunflower in hermetic silo-bags. In: Proceedings of the International Grain Quality and Technology Congress 15e18 July 2008, Chicago, Illinois,USA.
9. Bashir. E.M. and Shafie, H.A.F.(2013). Insecticidal and antifeedant Efficacy of *Jatropha* oil extract against the Desert Locust, *Schistocerea gregaria* (forskal) (Orthopthera Acrididae). *Agricultural and Biology Journal of Northern Nigeria.* 4(3): 260-267
10. Bayih, T. (2014). Synergistic bio-efficacy of insecticidal plants against bean bruchids (*Zabrotessubfasciatus*: Coleoptera) a major storage pests of common bean (*Phaseolus vulgaris* l.) in central rift valley of Ethiopia.
11. Boateng, B. A. and Kusi, F. (2008). Toxicity of jatropha seed oil to *Callosobruchus maculatus*(coleopteran Bruchidae) and its parasitoid , Dinarmusbasalis (Hymenoptera ; pteromalidae). *Journal of Applied Sciences Research 4*(8);945-951
12. Caswell GH, Akibu, S (1980). The use of pirimipho-methyl to control bruchids attacking selected varieties of stored cowpea. Trop. Grain Legume Bull., 17/18: p. 9-11.
13. Chijindu, E.N. and Boateng, B.A. 2008. Effect of Nutritional content of processed cassava Chips on Development of *Prostephanus truncatus* (Horn). *World Journal of Agricultural Sciences* 4(3): 404-402
14. Danjuma B.J., Majeed, Q.,Manga, S. B., Yahaya, A., Dike, M.C and Bamaiyi, L.(2009). Effect of some plant powders in the control of *Sitophilus zeamais* motsch (Coleoptera: curculionidae) infestation on maize grains *American-Eurasian journal of Science research ,*4(4):313-316
15. Dawit , K. Z. and Bekelle , J.,(2010). Evaluation of orange peel *Citrus sinensis* (L) as a a source of repellent, toxicant and protectant against *Zabrotessub fasciatus*(Coleotera: bruchidae).*Mekelle University jounal of Science,* 2(1): 61-75.
16. Devi, M. B. Devi, N. V. (2014). Biology and morphometric measurement of cowpea weevil, *Callosobruchus maculatus* (F) (Coleoptera: Chrysomelidae) in green gram. *Journal of Entomology and ZoologyStudies 2 (3): 74-76.*
17. Dramani, K. (2010). Comparative study of cowpea storage in different storage structures. Project report submitted to the Department of Agricultural engineering.
18. Dzemo. W.D; Niba, A.S and Asiwe, J.A. N (2010). Cowpea production., *African journal of Biological Technology.* 9(11): 1673-1679
19. Elhag, E. A.(2000). Deterrent effect of some botanical products on oviposition of cowpea bruchid *Callosobruchus maculatus*(F.) (Coleoptera :Bruchidae). *International Journal of Pest Management,***46**(2):109-113.
20. Epidi, T.T., Udo I.O. and Osakwe, J.A. (2009), Susceptibility of *Sitophilus zaimais* (mosts) and *Callosobruchus maculatus* (F). To plant parted of *Ricinodendron heudelotic. Journal of Plant Protection Research,***49** (4):53-58
21. Faliki, A.M., Miko, S., Mohammed, I.B. Abubarka, I.U., Valentia, J.A. 2009. Evaluation of some improved bread wheat varieties at Chiyako, Jigawa State, Nigeria. *Journal of Agriculture and Biological Sciences* 4:1-4.
22. FCDP, (2005). Food Crops Development Project. Cowpea Production Guide, pp 35-38. Amayen Press, Ghana
23. Food and Agriculture Organization of the United Nations (FAO). 2008. World paddy production. http://www.fao.org/newsroom /en/news/2008/1000820/index.html. Accessed 26 March 2017.
24. G. Vardar-Ünlü, F. Candan, A. Sökmen, D. Daferera, M. Polissiou, M. Sökmen, E. Dönmez, B. Tepe. (2003). Antimicrobial and antioxidant activity of the essential oil and methanol extracts of Thymus pectinatusFisch. etMey. Var. pectinatus (Lamiaceae). Journal of Agricultural and Food Chemistry. 51(1): 63-67
25. Gungula, D. T and Garjilla, Y (2005). The effects of phosphorus application on growth and yield of cowpea in *jounal of sustainable development in agriculture environment*.i(1)
26. Iloba, B. N. Umoetok, S. B. A. and Keita, S. (2007). The biological control of the *Callosobruchus maculatus*(Fabricius) by *Dinarmus basali* (Rendani) on stored cowpea *Vigna unguiculata*(L.) Walp. seeds. *Research Journal of Applied Sciences 2(4): 397-399.*

27. Kayode D. IIeke andOlaniyi C,O (2013). Entomocidal activity of powders and extracts of four (4) medicinal plants against *Sitophilus oryzae, Oryzaephilus Mercator(*Faur) and *Ryzoperthadominca*(Fabr).*Jordan Jounal of Bioscience,* Vol 7 .10;57-62
28. Langyintuo, A. S. Lowenberg-DeBoer, J. Faye, M. Lambert, D. Ibro, G. Moussa, B. Kergna, A. Kushwaha, S. Musa, S. Ntoukam, G. (2003). Cowpea supply and demand in West and Central Africa. *Field Crop Research 82:215-231.*
29. Mahama, S. (2012). *Comparative Assessment of some Storage Technologies used for cowpea storage in the Nadowli District of the Upper West Region of Ghana.* MSc. Thesis Department of Horticulture Kkwame Nkrumah University of Science and Technology, Kumasi. Pp75.
30. Muhammad Yasin Ibrahim (2012).” Efficacy of some plant oils against three storage pest on chickpea seeds”. *Persian Gulf Crop Protection.*vol 1 (1); 4-11
31. Mukanga M, Deedat Y and Mwagala F.S (2010). Toxic effect of five (5) plant extracts against the larger grain borer, *Prostephanus truncates. African Journal of Agriculture Research.* Vol 5(24); 3369-3371
32. Murdock LL.(2007). A novel method forconservating cowpea germplasm and breeding stock using solar disinfestations *Journal of Stored Products Research*.33:175-179.
33. Musa, A.K. (2007). Control of *Callosobruchusmaculatus*(F.) (Coleoptera: Bruchidae) in stored cowpea with *Piper guineense*Schum. &Thonn. *Journal of Tropical Biosciences 7*: 20-23.
34. Mustapha M ,Hussain H, Hussain M.A, Biswas P.K and M.Z(2012). Insecticidal activity of plant extracts against *T. casteneum. Jounal of Advanced Scientific Research* .3(3);80-84
35. N.G. Tzortzakis, C.D. Economakis. (2007). Antifungal activity of lemongrass *(Cympopogon citratus* L.) essential oil against key postharvest pathogens. Innovative Food Science & Emerging Technologies. 8(2): 253-258. [3] B.T. Schaneberg, I.A. Khan. (2002
36. Ndoutoume-Ndong, A. and Rojas-Rousse, D. (2008). Rôle de l’intensitélumineusesur les capacities parasitairesd’Epelmusorientalis Crawford et d’Epelmusvuilleti Crawford,
37. Nwaubani, S.I., Opit, G.P., Otitodun, G.O. and Adesida, M.A. 2014. Efficacy of two Nigeria derived diatomaceous earths against *Sitophilus oryzae*(Coleoptera: Curculionidae) and *Rhyzoperthadominica* (Coleoptera: Bostrichidae) on wheat. *Journal of Stored Products Research* 59: 9-16
38. Ofuya, T.I. (2003). Biology, ecology and control of insect pest of stored legumes in Nigeria. In: Pests of stored cereals and pulses in Nigeria: Biology, ecology and control. Edited by T.I Ofuya, N.E.S. Lale, Dave Collins Publication Nigeria, 24-58.
39. Ogunleye R.F., Adedire C.O and Adesuyi S.A. (2004). Toxicity of some underutilized tropical plants to the storage pest of maize, *Sitophilus zeamaise* (Mots.) (Coleoptera:Bruchidae), *Journal of Biology. Physical Sciences* 2(1). 22-27
40. Oguntade T.O. and Adekunle A.A.(2010). Preservation of seeds against fungi using wood-ash of some tropical forest trees in Nigeria, *African Journal of Microbiology. Research.*4(4) ,279-288.
41. Omotoso O.T. (2008). Efficacy of exracts of some aromatic medicinal plant on cowpea bruchid, *C. maculatus*in storage. *Bulletin of insectology* 16(1);21-24
42. Opoaraeke, A.M., Dike, M.C. and Amatobi, C.I. (2002). Preliminary investigation of clove, *Syzygiumaromaticum*(L.) Merr. andPerr. as a source of valuable insecticide for field pest control on cowpea. *Nigeria Journal of Agricultural Extension n* 13: 178-181.
43. Organization for Economic Co-operation and Development (OECD) (2015). *Consensus document on the biology of cowpea* (*Vigna unguiculata* (L.) Walp.). Series on Harmonisation of Regulatory Oversight in Biotechnology No. 60. *Environmental Journal of Microbiology 48:44*
44. Parwada C, Gadziray C, Karavina ,C, Kubiku F, Mandumbu R and Madumbu B,Z(2012). *Tagetesminuta* formulation effect on *Sitophilus zeamais* control in stored maize grains *International Jounal of Plant Research* 2(3); 65-68 DOI; 10:59231j. plant.20120203.04
45. Rahman , A, and Tlukder, F.A (2006).Bioefficacy of some plant derivatives that protect grains against the pulse beetle,*Callosobruchusphaseoli. Journal of Stored Products Research,*35: 285—295
46. Rajapakse R. H, S (2006). The potential of plants and plant product s in stored insect pest management. *The journal Agricultural Sciences* 12(1) Rijksuniv. Gent 57 (3), 751–758.

47. S. Amirdivani, A.S. Baba. (2011). Changes in yogurt fermentation characteristics, and antioxidant potential and in vitro inhibition of angiotensin-1 converting enzyme upon the inclusion of peppermint, dill and basil. LWT-Food Science and Technology. 44(6): 1458-1464.
48. Soundararajan, R. P. 1. Chitra, N. Geetha, S. and Poorani, J. (2012). Biological control of bruchid *Callosobruchus maculatus* (F.) in blackgram. *Journal of Biopesticides 5: 192-195*
49. Stejskal, V. Aulicky, R. and Kucerova, Z. (2014). Pest control strategies and damage potential of seed-infesting pests in the Czech stores – a Review. *Plant Protection Science 50(4): 165–173.*
50. Timko MP, Gowda BS, Ouedraogo J, Ousmane B (2007). Molecular markers for analysis of resistance to *Striga gesnerioides* in cowpea. In Ejeta G Gressell J (eds) integrating New technologies for *Striga* control: Towards Ending the Witch- hunt, World scientific publishing Co. pte Ltd, Singapore, pp. in press.
51. Tran, B. M. D. and Credland, P. F. (1995). Consequences of inbreeding for the cowpea seed.
52. Umar YF (2008). Comparative potential of Leaf, Bark and Wood powders of *Joctropha cuncas* (L) as protectants of stored cowpea against *Callosobruchus maculatus* (F). Savannah *Journal of Agriculture,* 3:86-92.
53. Vanmathi J.S., Padmalatha, C., Ranjit Singh, A.J.A. and Chaiman, K. (2012). Effect of chosen botanicals on the oviposion deterrence and adult emergence of *Callosobruchus maculatus* (F.) (Coleoptera: bruchidae). *Elixir Bio Technology International Journal,* 51(A):11120-11123
54. Wang, Yang, Easteal, A.J., Dong Chen, X., 1998. Ethylene and oxygen permeability through polyethylene packaging films. Packaging Technology and Science 11, 169e178.
55. Zaka S,M, Zeng X,N, Holford P and Beattie G, A,C (2010). Repellent effect of guava leaf volatiles on settlement of adult of Citrus psylla, *Diasphorinacitri*k uwayama, on citrus. *Insect science* 17;39-45.