The Effectiveness of Plant extracts and Diatomaceous earth powder on the Mortality of Weevils (Callosobruchus maculatus) of stored Cowpea in Makurdi, Benue State. Nigeria

Iyough, D. D., Akinyemi B. K. and Madina, P.,
Department of Crop Production,
College of Agronomy, Joseph Sarwun, Tarka, University Makurdi, Nigeria;
Email. madnapaul26@yahoo.com Mobile number: +2348062138676

DOI: 10.56201/rjfsqc.v10.no1.2024.pg59.72

Abstract
Weevils (Callosobruchus maculatus) a major storage insect pest of cowpea, lays its eggs on the pods or sometimes on the seeds both in the field and in storage. The larva perforates the seeds and completes its life cycle there. It can cause loss, if not controlled in time. The objective of this project was to examine the effect of plants extracts (Diatomaceous earths, Neem seed powder and Moringa seed powder) on cowpea weevils as an alternative for preserving cowpea at storage at Makurdi. The experimental design for the study was Completely Randomized Design with three replications. Data collected included; Bruchid mortality, population of progeny, number of perforated seeds, seeds weight, Germination percentage and seedlings establishment at 4 weeks and 12 weeks. Significant difference (P<0.05) was recorded on cowpea variety and plant extracts were Sampea 11 (white cowpea) recorded high bruchid mortality, seed weight and seedling establishment with low number of perforated seeds and Sampea 12 (brown cowpea) having high germination percentage. On plant extracts, Diatomaceous earths recorded the high mortality, seed moisture, and seedling establishment with low number of perforated seeds on the other hand Neem extracts recorded the lowest in seed weight loss. Hence, Sampea 11 (white cowpea) variety shows superiority over Sampea 12 (brown cowpea) variety in bruchid mortality, seed weight and seedling establishment and low number of perforated seeds over Sampea11. While sampea 12 also outperformed sampea 11 in germination percentage on plant extracts the use of Diatomaceous earths is superior in all the parameters measured except in seed weight lost. Therefore, the use of Diatomaceous earths powder by cowpea farmers for effective control of cowpea weevils in storage and the adoption Sampea 11 (white cowpea) variety since it has resistance to cowpea weevils during storage should be encourage to farmers in the study location.

***Key words**: Plant extracts, Diatomaceous earths, Control, and Bruchid*

Introduction

Cowpea (*Vigna unguiculata* (L.) Walp) is an important food legume and an essential component of cropping systems in the drier regions of the tropics (Oyeyinka et al., 2013). Being a fast growing crop, cowpea curbs erosion by covering the ground, fixes atmospheric nitrogen, and its decaying residues contribute to soil fertility (Oyeyinka et al., 2013). In West and Central Africa, cowpea is of major importance to the livelihoods of millions of people providing nourishment and an opportunity to generate income (Latunde-Dada et al., 1999). Cowpea powders, in particular, are cost-effective and versatile and can be used in nearly any application such as in snack foods, cereals, dips and even cookies. Bean powders offer the same nutritional benefits as whole, prepared beans (Mitchell, 2009).

However, Cowpea is one of the grains that suffer postharvest losses most, it suffers heavily from insects, both in the field and when grains are stored after harvest. The main pest during the growing season is the aphids while the main storage pest is the bruchids. The primary insects causing losses to stored cowpeas in West Africa is the cowpea weevil. Infestation begins in the field at low level and then after the crop is placed in the storage, the insect's population continues to grow until the cowpea is completely damaged (Ilesanmi and Gungula, 2010). Cowpeas play a key role in the agriculture and food supply of Nigeria. In the 1990s, Nigeria accounted for about 45 percent of the world's cowpea production (FAO, 2006). As at 2004, it was also the world's largest cowpea importer, with annual imports of around 300,000 metric tons from neighboring countries (FAO, 2006). Niger was the largest single source of cowpeas imported to Nigeria in the 1990s, with around 260,000 metric tons per year. The major producing countries in Africa are Nigeria, Senegal, and Tanzania (FAO, 2006)

Cowpea is usually stored in sacks or in some indoor structure that is specifically dedicated to cowpea storage and usually stored for up to 2 to 3 months. Wholesalers often hold cowpea stocks for extended periods waiting for higher prices (Salifu, 2012). Cowpea suffers substantial damage and loss of quality as a result of infestation by Callosobruchus maculatus (Golob *et al.*, 1999). Singh and Jackai (1985) noted that, on-farm storage of cowpeas for 6 months is accompanied by about 30% loss in seed weight, with about 70% of the seeds being damaged and virtually unfit for consumption. Cowpea suffer heavy insect damage, more than 30% while stored on the farm, losses can exceed 10% by weight (Golob et al., 1999). Insect damage is clearly substantial during storage both on-farm and at the market ranging from 2.6% to 70% on average (Golob *et al.*, 1999). About 4 percent of total annual production of cowpea or about 30,000 tonnes valued over 40 million US dollars is lost annually to the cowpea bruchid in Nigeria alone (Singh et al., 2000). Severe infestation can lead to total grain loss in storage. Cowpea weevil, been a field-to-store pest; adult beetles lay eggs on pods (in the field) or on seeds (in storage). After hatching, the larvae develop within seeds and eat up the cotyledon, thereby causing extensive damage. Adults emerge from the seeds through characteristic holes made by the larvae (IITA, 2009). Musa and Adetunji (1999) reported that in Nigeria, consumers shy away from holder grain, especially cowpea.

Diatomaceous earth (DEs) are geological deposits consisting of the fossilized skeleton of numerous species of siliceous marine and fresh water unicellular organisms, particularly diatoms which are the most widespread group of plants on earth with more than twenty five thousand species of different morphologies (Massiwa, 2004). The different species of diatomaceous extracts silicon from water to produce a hydrated amorphous silica skeleton which sink to the bottom when the diatoms die and over centuries these shells form thick layers which when fossilized and compressed give rise to a layer of soft-chalky rock that is termed Diatomaceous earths (Quarles and Winn, 1996). On extraction of the chalk rock, it contains 50% or more moisture content with between 86 and 94% silica (Quarles, 1992). Upon processing of the raw material the moisture content is reduced to between 2 and 6%. Particles size is also reduced by crushing or milling and sieving a process known as pulverizing which reduces particle size to between 0.5 and 100 millimeters (Quarles, 1992). Crushing is done so as to increase the insect chances of picking up the dust. Drying allows ability of the dust to adhere to grain coat and insect cuticle.

Diatomaceous earths vary in colour depending on composition from white grey to yellow red with amorphous silicon dioxide being the active ingredient. Research on the efficacy of DEs has been done on numerous insects such as ants, textile pests, termites, poultry mites and ticks (Masiiwa, 2004). Different and often completely opposite results were obtained but however, there was a general conclusion that can be drawn from these conflict results. The sensitivity of store product insects to DEs varies with species. Pest in the genus Cryptolestes being more sensitive and Sitophilus species less susceptible followed by Rhyzopertha dominica and Tribolium species which appear most in almost any dry interior environment, including empty storage containers, bins and elevators (Quarles Winn, 1996). Typically, it is used for cracks and crevice treatment but can also be used on surface as along as it stays dry. DEs either repel or kill insects that come in contact with them on dry surfaces.

Moringa oleifera is an important food commodity which has received attention as the natural nutrition of the tropics'. The leaves, fruit, flowers and immature pods of this tree are used as a highly nutritive vegetable in many countries, particularly in India, Pakistan, Philippines, Hawaii and many parts of Africa (Anwar et al., 2005).

Neem is known for its "bitter taste" due to the principal active ingredient azadirachtin, which is the most active ingredient. It possesses antifeedant, repellant, growth disrupting and larvicidal properties against a large number of pests (Mathur, 2013). The toxicity of neem to stored products insects is attributed to the presence of many chemical ingredients, such as triterpenoids, which include azadirachtin, salanin, meliantriol (Ileke and Oni, 2011). Neem grain powder reduces adult beetle emergence and grain damage as a result of high mortality of adult insects by blocking spiracles, inhibit locomotion, which disrupt mating and sexual communication as well as deterring females from laying eggs and complete suppression of the developmental stages of insect (Ileke and Bulus, 2012). The other limonoids, such as meliantriol, salanin, nimbin and nimbidin have been found in traces and contribute to overall bioactivity (Morgan, 2009). Azidrachtin has a wide spectrum of actions, such as repellent, antifeedant, insect growth regulatory (IGR), anti-ovipositional, fecundity and fitness reducing properties on insects (Schmutterer, 1990). The IGR effects, manifested in growth and moulting abnormalities, result from the disruption of the endocrine system by blocking the release of neurosecretory peptides that regulate synthesis and the release of ecydysteroides and juvenile hormone, and the direct effects of azadirachtin on dividing cells (Mordue et al., 1993).

The aim of the research is to determine the efficacy of plant extracts in the storage of cowpea in Benue Makurdi Nigeria.

Material and methods

This study was conducted at Strategic Grain Reserve (SGR), Federal Ministry of Agriculture Makurdi. SGR is located in Makurdi the administrative headquarter of Benue state, lies approximately between latitude 7o44'N and longitude 8o 54'E. The town is located along the coast of the River Benue. The design of the experiment was 2×3×4 factorial in a completely randomized design (CRD) with three replications. The experiments were setup using non-infested cowpea seeds. Two plant powders and Diatomaceous earth powder were used against two cowpea cultivars. The experiment contains seventy two treatments, the powders weighing 5g were used against 100g cowpea seeds and the untreated control. Mortality readings for the bruchids were taken at 24, 72, 120 and 168 hours after setting the experiment. This involved

the counting and removal of all the dead insects. Cold Sterilized trays; soft forceps together with hands were used. Care was taken to retain all the live insects in their respective jars together with the seeds and the powder. Much attention was given to the infested grain for some insects tended to hibernate in grain cavities. Numbers of dead and live insects were recorded then the dead insects were discarded. The test for progeny emergence took place at week 4, week 8 and week 12 for F1, F2 and F3 respectively, when the newly emerged adults were sieved out and recorded. The data obtained from progeny emergence were analysed statistically and compared with the control and with one another. The weight of the containers was first taken and recorded and the weights of the plant botanicals were also taken. The data collected were progressive weight loss of the cowpea varieties at weekly intervals. The weight loss was measured using a digital sensitive weighing balance. The mean weight of the cowpea variety was also determined at two weekly intervals.
Percentage weight loss was calculated as prescribed by Ogbaji and Osuman (2011) as follows:

$$Percentage\ weight\ loss = \frac{initial\ weight - final\ weight}{initial\ weight} \times \frac{100}{1}$$

For each variety, the percentage weight loss was calculated for the variety at weekly intervals during the experimental period. From the initial weight, the mean percentage weight reduction of the cowpea varieties was also calculated
The moisture content of the cowpea was determined prior to the experiment and after the experiment using Dickey John multi-grain moisture metre. The initial moisture content of SAMPE 11 was 7.8 while SAMPEA 12 was 8.2. At the end of the experiment, the percentage Moisture content (M.C) of each sample was calculated as follows:-

$$\%M.C = \frac{Initial\ sample\ moisture\ content - Final\ sample\ moisture\ content}{Initial\ sample\ moisture\ content} \times 100$$

Germination test was carried out at the end of the experiment by randomly picking 60 seeds from each treated group and the control. They were placed separately on a moistened filter paper (Whatman No.1) in Petri dishes and kept at room temperature. Moisture was added to keep the filter papers wet on a daily basis. This was necessary because, cowpea possesses a hard testa and required adequate moisture in order to germinate. Each treatment was replicated three times where healthy untreated grains were used as a control. The numbers of germinated grains were recorded starting from the first date of germination and statistically compare with control and with one another

$$Germination\ \% = \frac{number\ of\ seeds\ that\ germinated}{total\ number\ of\ test\ seeds\ placed\ in\ petri\ dish} \times 100$$

Seedling length (cm): On seventh day of germination test, ten normal seedlings were taken out carefully at random from each treatment from all the replications and measured both the root and shoot length. The average of ten seedlings was calculated and expressed as mean seedling length in centimetre
Seedling vigour index: The seedling vigour index was calculated using the formula prescribed by Abdul Baki and Anderson (1973) and expressed in number.

$$Seedling\ Vigour\ Index = seedling\ length\ \times germination\ \%$$

Data was analyzed with analysis of variance (ANOVA) using GENSTAT Release 10.3DE (Copyright 2011, VSN International Limited, Rothamsted Experimental Station) while means were separated using Least Significant Different (LSD) at 5% level of probability.

Result and discursion

Table 1: Main effects of cowpea variety and powder type on bruchid mortality and population progenies

	Bruchid Mortality (%)				Population of Progenies		
Variety (V)	**24 HAE**	**72 HAE**	**120 HAE**	**168 HAE**	**4WAE**	**8WAE**	**12WAE**
SAMPEA11	25.52	52.80	67.90	72.50	17.90	15.00	23.90
SAMPEA12	14.06	35.90	58.90	62.30	13.60	16.90	45.80
F-LSD (0.05)	13.54	5.59	5.81	5.81	NS	NS	20.05
P-value	<0.001	<0.001	0.003	<0.001	0.083	0.435	0.033
Powders (P)							
Diatomaceocous Earth	13.54	56.80	79.20	80.50	12.80	16.20	33.30
Moringa leaf powder	14.32	30.50	46.60	51.70	16.90	17.70	42.30
Neem Leaf Powder	31.51	46.40	64.30	70.10	17.50	14.00	28.80
F-LSD (0.05)	2.85	6.84	7.17	7.12	NS	NS	NS
p-value	<0.001	<0.001	<0.01	<0.001	0.243	0.464	0.535

F-LSD= Fisher's Least Significant Differences at 5% Level of Probability
HAE= Hours after exposure to power; WAE= Weeks after exposure to powder
NS= Not significant

This table presents data on the main effects of cowpea variety (V) and powder type (P) on bruchid mortality at different time points and the population of progenies. Comparative study of the effectiveness of two plant powders (Neem leaf and Moringa leaf powders) and Diatomaceous earth in preservation of two varieties of cowpea against *Callosobruchus maculatus* was carried out.

Significantly higher mortality (P<0.05) of the weevils was observed in SAMPEA 11 variety of cowpea as compared to SAMPEA 12 variety. The percentage of progeny emergence from container of SAMPEA 12 variety were significantly higher (P<0.001) compared with those of SAMPEA 11 containers, except for progenies population at 4 weeks after exposure (WAE) to the powders. Comparatively, significantly higher mortality of C.maculatus observed in SAMPEA 11variety of cowpea in this study as compared to SAMPEA 12 variety of cowpea is an indication of inherent variation in genetic factors between the two seed varieties used. It is well known that the grains used for rearing insects usually influence their physiology by inducing different arrays of enzymes to a varying extent (Oyeniyi *et al.*, 2015). Interestingly, Gbaye and Holloway (2011) demonstrated that the cowpea variety on which C. maculatus is reared influences tolerance to malathion. With this, a varietal effect on tolerance to natural insecticides is perhaps less surprising. Esang *at al*., (2022) reported that genetic make-up could have brought the variability in insect infestation.

Mortality of the bruchids in containers containing diatomaceous earth powder was significantly higher (P< 0.001) compared with those that contained Moringa leaf powder and Neem leaf powder all through the 168 hours period of evaluation. The high level of significance was brought about by Moringa leaf powder. In addition, at 24 hours after exposure (HAE), it was Neem leaf powder that brought about the highest mortality (*P* <0.001) when compared to that of Diatomaceous earth powder and Moringa leaf powder. this accretion is supported by the finding of Kaita *et al*. (2010) who agrees with the report of this work stating that Neem power has a component that inhibit weevils activities and proliferation in stored cowpea. The progeny emergence observed in all the treated containers was not significantly different (*P* > 0.05) from each other all through the 12 weeks period of evaluation.

Table 2: Main effects of cowpea variety and powder type on number of seeds perforated, seed weight loss and increase in seed moisture content

	Number of seed perforated			**Seed Weight Loss (%)**			
Variety (V)	**4 WAE**	**8 WAE**	**12 WAE**	**4 WAE**	**8 WAE**	**12 WAE**	ISMC
SAMPEA11	14.36	31.80	41.90	2.86	9.56	18.49	7.07
SAMPEA12	15.11	31.30	48.00	2.47	6.94	18.22	6.79
F-LSD (0.05)	NS	NS	6.00	NS	1.713	NS	0.05
P-value	0.618	0.839	0.045	0.254	0.004	0.710	<0.001
Powders (P)							
Diatomaceocous Earth	15.12	30.30	41.70	2.96	8.96	17.96	6.80
Moringa leaf powder	13.62	33.50	50.30	2.25	9.79	20.96	7.07
Neem Leaf Powder	15.46	30.80	42.90	2.79	5.96	16.54	7.05
F-LSD (0.05)	NS	NS	7.34	NS	NS	3.474	0.06
p-value	0.569	0.548	0.045	0.210	0.002	0.041	<0.001

F-LSD= Fisher's Least Significant Differences at 5% Level of Probability
WAE= Weeks after exposure to powder ISMC= Increase in seed moisture content,
NS= Not significant

Table 2 is the numbers of seeds and seed weight where significant difference (P<0.05) was observed with perforation in SAMPEA 11 cowpea variety and SAMPEA 12 variety were not significantly different (*P* > 0.05) from each other, except at 12 weeks after exposure (WAE) where SAMPEA 12 variety brought about the highest number of seeds perforated. Furthermore, the percentage seed weight loss from containers containing SAMPEA 11 variety were not significantly different (*P* >*0*.05) from seeds in SAMPEA 12 containers, except for percentage weight loss at 8 weeks after exposure. Percentage change in moisture content in SAMPEA 11 variety of cowpea was significantly different compared with SAMPEA 12 variety, this could be associated with genetic make-up of the seeds, seed coat and other phytochemical component as reported by Ewete *et al*., (1996) who stated that, phytochemical component and genetic make-up affect the seed vulnerability to insect pest attack both in field and in storage.

The result on different powders used showed no significant difference in the number of seeds perforated throughout the storage period except at 12 weeks after exposure (WAE) where Diatomaceous earth had the least percentage number of seeds perforated. The high significance was therefore brought about by Moringa leaf powder. Then the Seed weight loss was significantly lower in containers treated with Neem powder all through the period of evaluation except at 4 WAE where there was no significant difference among treatments. This finding is in line with that of Ekeh *et al.*, (2013) that aromatic compound such as terpineol, glycosides, saponin and flavonoid have ovicidal, toxic and deterrent effects on stored product coleopterans. This work is a par with the work of Esang *et al.*, (2022) who reported higher mortality of bruchids observed under Neem treatment could be attributed to irritating smell of its components that causes suffocation or death of adult C.maculatus, thereby, preventing physical contact or hindering ovipositor success. This agrees with the findings of Mathur (2013) who reported that Neem was known for its "bitter taste" due to the principal active ingredient azadirachtin, which is the most active ingredient. It possesses antifeedant, repellent, growth disrupting and larvicidal properties against a large number of pests. However, this irritating smell decreases with exposure time. This is in agreement with Oyeniyi *et al.*, (2015) also found that potency of the plant powders decrease with exposure time.

However, increase in seed moisture content was significantly lower ($P < 0.001$) in seeds treated with Diatomaceous earth while Moringa powder had the highest increase in seed moisture content. The results suggest that the choice of cowpea variety and powder type influences seed perforation, weight loss, and Increase in seed moisture content, with significant variations observed at specific time points. This agrees with the work of Madina *et al.*, (2022) who stated that plant extract use in storage affect the moisture content. These findings have implications for pest management strategies and seed quality preservation in cowpea storage.

Table 3: Main effects of cowpea variety and powder type on germination count and seedling vigour of cowpea

	Germination count (%)			Seedlings (cm)		
Variety (V)	**3 DAP**	**4DAP**	**5DAP**	**Root length**	**Shoot length**	**Vigour**
SAMPEA11	32.10	81.11	82.92	5.79	3.32	767.00
SAMPEA12	0.10	87.64	88.47	3.67	2.41	541.00
F-LSD (0.05)	8.25	3.82	3.07	0.57	0.28	67.80
P-value	<0.001	0.001	<0.001	<0.001	<0.001	<0.001
Powders (P)						
Diatomaceocous Earth	20.20	85.21	90.83	4.77	2.78	660.00
Moringa leaf powder	13.80	83.54	93.06	4.96	2.80	660.00
Neem Leaf Powder	14.40	84.38	92.22	4.45	3.02	642.00
F-LSD (0.05)	NS	NS	66.67	NS	NS	NS
P-value	0.373	0.759	<0.001	0.669	0.327	0.88

F-LSD= Fisher's Least Significant Differences at 5% Level of Probability
DAP= Days after planting, NS= Not significant

Table 3: Main effects of cowpea variety and powder type on germination count and seedling vigour of cowpea, The results indicate that both cowpea variety and powder type significantly impact germination count and seedling vigor Germination count was significantly higher (P <0.05) in SAMPEA 12 variety of cowpea compared to SAMPEA 11 except at 3 DAP where SAMPEA 11 variety was higher. However, Seedlings root length, seedling shoot length and seedling vigour index were significantly higher (P <0.001) in SAMPEA 11 variety compared with SAMPEA 12 variety of cowpea. The results of this study are in conformity to some degree with the report of some workers, like Opareke and Dike (2005), Adedire *et al*. (2011), Mukanga *et al.* (2010), Ileke and Oni (2011), who observed that certain botanicals promote germination count and seedling vigor of cowpea while other botanicals are toxic and inhibit germination, seedlings root length, seedling shoot length and seedling vigour index.

Among the powders, Moringa Leaf Powder and Diatomaceous Earth show comparable effects on seedling characteristics, while Neem Leaf Powder has a slightly lower impact. This could be true since plant extract don't have effects on seed viability, germination, seedling establishment postulated by Madina *et al.*, (2023). These findings have implications for selecting optimal varieties and powders to enhance the early plant establishment and growth stages of cowpea plants.

Table 4: Interaction effect of variety and powder type on bruchid mortality and population progeny

		Brucid mortality (%)			**Population of progenies**			
Variety	**Powders**	24 HAE	72 HAE	120 HAE	168 HAE	4 WAE	8 WAE	12 WAE
SAMPEA 11	Diatomaceocous Earth	12.50	59.40	79.70	81.80	11.80	16.20	26.80
	Moringa leaf powder	15.63	37.00	55.20	60.70	22.70	19.30	20.40
	Neem Leaf Powder	48.44	62.00	68.80	75.00	19.20	9.50	24.30
SAMPEA 12	Diatomaceocous Earth	14.58	53.10	78.60	79.20	13.80	16.30	39.80
	Moringa leaf powder	13.02	24.00	38.00	42.70	11.10	16.10	64.20
	Neem Leaf Powder	14.58	30.70	59.90	65.10	15.80	18.40	33.30
	F-LSD (0.05)	4.03	19.35	NS	NS	NS	NS	NS
	P-value	<0.001	0.002	0.088	0.106	0.087	0.128	0.304

F-LSD= Fisher's Least Significant Differences at 5% Level of Probability
HAE= Hours after exposure to power; WAE= Weeks after exposure to powder
NS= Not significant

Mortality was significantly higher (P <0.001) in SAMPEA 11 containers treated with Diatomaceous earth all through the 168 hours period of evaluation except at 24 HAE where SAMPEA 11 seeds treated with Neem leaf powder brought about the highest bruchid mortality which was significantly different from that of the other treatments. This agrees with earlier observation by Ileke and Oni (2011) which reported similar trend against S. zeamais in wheat grains. High mortality of weevils was observed in cowpea treated with Diatomaceous earth at all doses under investigation. Little or no mortality was expected in the untreated control however, reasonable mortality was observed as a result of variation in genetic factors of the cowpea varieties and other environmental factors which were minimized for firm result to be obtained.

The results highlight the complex interaction effects between cowpea variety and powder type on bruchid mortality at different time points. Diatomaceous Earth generally exhibits lower mortality rates, while Moringa Leaf Powder and Neem Leaf Powder show varying impacts on bruchid mortality and population progenies. These findings provide insights into the potential effectiveness of specific powders in controlling bruchid infestation and population growth, with implications for pest management strategies in cowpea cultivation. Most plants extracts powder may as well be used for controlling the storage pest since they pose minimal risk to consumers and the environment. Adedire (2003) disagree with the finding in this work stating that plant extracts may affect the taste of the seeds in storage making it not accepted in the market. Although all plant extracts are significant at ($P<0.05$) this revealed that all the tested plants extracts were not toxic and could be used for cowpea storage.

However, progeny population observed in all the containers with the two cowpea varieties treated with the different powders were not significantly different ($P > 0.05$) from each other all through the 12 weeks period of evaluation (Table 4). The study supports the statements of other researchers that reported less progeny at high dose and longer exposure intervals (Athanassiou *et al.*, 2003; 2005). The high population of progeny observed at the termination of the experiment (F3) could be as a result of reduction in the potency of the powders and also the high moisture content of the seeds since it was already beyond save moisture content. Higher relative humidity also affects Diatomaceous earth efficacy and renders the stored seeds more susceptible to bruchid attack. This agrees to the findings of Korunic, (1996) who reported that grains moisture content should be less than 14.5% so that the insects would not have a constant source of water to replace loses due to Diatomaceous earth action of dehydrating the insect.

No significant differences in population progeny at 4 WAE, 8 WAE, and 12 WAE.

Table 5: Interaction effect of variety and powder type on bruchid induced damage and seed moisture

		Number of seeds perforated			Seed weight loss (%)			
Variety	**Powders**	4WAE	8 WAE	12 WAE	4 WAE	8 WAE	12 WAE	ISMC (%)
SAMPEA 11	Diatomaceocous Earth	13.17	30.50	36.40	3.00	10.17	16.42	6.72
	Moringa leaf powder	17.67	38.60	50.30	2.67	13.17	23.75	7.27
	Neem Leaf Powder	12.25	26.30	39.00	2.92	5.25	16.08	7.23
SAMPEA 12	Diatomaceocous Earth	17.08	30.20	46.90	2.92	7.75	19.50	6.63

Moringa leaf powder	9.58	28.50	50.40	1.83	6.42	18.17	6.87
Neem Leaf Powder	18.67	35.20	46.80	2.67	6.67	17.00	6.86
F-LSD (0.05)	5.20	9.00	NS	NS	2.96	4.91	0.09
P-value	<0.001	0.017	0.350	0.636	0.001	0.041	<0.001

F-LSD= Fisher's Least Significant Differences at 5% Level of Probability
WAE= Weeks after exposure to power; WAE= Weeks after exposure to powder
ISMC= Increase in seed moisture content, NS= Not significant

The number of seeds perforated was significantly higher (P <0.05) in SAMPEA 12 variety except at 8 WAE where SAMPEA 11 seeds treated with Moringa leaf powder brought about the highest bruchid mortality which was significantly different from that of the other treatments. In addition, the number of seeds perforated at 12 WAE was generally high but no significant difference was observed among the treatments. Seed weight loss was significantly higher (P <0.05) in SAMPEA 11 containers treated with Moringa all through the 12 weeks period of evaluation except at 4 WAE where there was no significant difference from that of the other treatments.

Increase in seed moisture content at the end of the experiment was significantly higher in cowpea seeds treated with Moringa powder (Table 5).

The results suggest significant interaction effects between cowpea variety and powder type on bruchid-induced damage, seed weight loss, and seed moisture content. Notably, differences in seeds perforated are apparent at 4WAE, while variations in seed weight loss and ISMC are observed at multiple time points. These findings provide valuable insights into the potential of specific powders to mitigate bruchid damage and preserve seed quality in cowpea cultivation

Table 6: Interaction effect of variety and powder type on cowpea seed germination and seedling vigor

		Germination count (%)			**Seedlings**		
Variety	**Powders**	3 DAP	4DAP	5DAP	Root length	Shoot length	Vigour
SAMPEA 11	Diatomaceocous Earth	40.40	81.67	83.33	5.53	3.06	723.00
	Moringa leaf powder	27.10	79.58	81.67	6.42	3.35	811.00
	Neem Leaf Powder	28.80	82.08	83.75	5.53	3.56	768.00
SAMPEA 12	Diatomaceocous Earth	0.00	88.75	89.58	4.11	2.50	598.00
	Moringa leaf powder	0.40	87.50	87.92	3.51	2.26	508.00
	Neem Leaf Powder	0.00	86.67	73.33	3.38	2.48	516.00

F-LSD (0.05)	NS	NS	NS	NS	NS	NS
P-value	0.345	0.759	0.814	0.088	0.234	0.097

F-LSD= Fisher's Least Significant Differences at 5% Level of Probability
DAP= Days after planting; WAE= Weeks after exposure to powder, NS= Not significant
At the end of seed germination test it was observed that, percentage Seed germination, seedlings root length, seedling shoot length and seedling vigour index observed in the two cowpea varieties treated with the different powders was not significantly different (P > 0.05) from each other all through the period of evaluation (Table 6). With combination of SAMPEA 11 and Distomaceocous earth having higher germination percentage, seedling establishment and seedling vigour, this could be attributed to seed viability and ability to absorb moisture as some seed exhibit which is uncommon with cowpea except if the condition is unfavourable, this finding is similar with the work of Dales (1996) who reported faster and high germination percentage in Sampea 11 variety after treatment with plant extracts. No significant differences in germination count and seedling vigour at 3 DAP, 4 DAP, and 5 DAP, the results indicate that there are no significant interaction effects between cowpea variety and powder type on seed germination and seedling vigour at different time points.

Conclusion

From the findings in these research it can be concluded therefore, the use of Diatomaceous earths powder by cowpea farmers for effective control of cowpea weevils in storage and the adoption Sampea 11 (white cowpea) variety since it has resistance to cowpea weevils during storage should be encourage to farmers in the study location.

References

Abetunji E. H. (1999). Persistence of some plant oils against the bruchid beetle, *Callosobruchus maculates* F. (Coleoptera: Bruchidae) during storage. *Journal of Agricultural Science*, 9(1): 423 – 432.

Anwar, T., and Basedow, T.H., Ofuya, T. I. Adeduntan, S. A. (2005). Laboratory and field studies on the effect of natural control measures against insect pests in stored maize in Ethiopia. *Journal of Plant Diseases and Protection*, 112 (2):156–172.

Adedire, B. (2003). Effect of five Botanicals on Oviposition, Adult Emergence and Mortality of *Callosobruchus maculatus* Infesting Cowpea. *Journal of Entomological Research.* 22(2):1 – 6

Adedire, S. A. Allen, F Atser, G and Ofuya, T. I. (2011). Evaluation of seeds of selected varieties of cowpea, *Vigna unguiculata* (L.) Walp. for susceptibility to *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae). Applied Trop. Agric., 3: 45-51.

Athanassiou, C.G., Kavallieratos, N.G., Tsaganou, F.C., Vayias, B.J., Dimizas, C.B., Buchelos, C.Th., (2003). Effect of Grain Type on the Insecticidal Efficacy of SilicoSec Against *Sitophilus oryzae* (L.) (Coleoptera: Curculionidae). Crop Protection 22, 1141-1147.

Athanassiou, C.G., Vayias, B.J., Dimizas, C.B., Kavallieratos, N.G., Papagregoriou, A.S., (2005) Insecticidal efficacy of diatomaceous earth against *Sitophilus oryzae* (L.)

(Coleoptera: Curculionidae) and *Tribolium confusum* Du Val (Coleoptera: Tenebrionidae) on stored wheat: influence of dose rate, temperature and exposure interval. *Journal of Stored Products Research* 41, 47-55.

Dalea, M. C. (1996). Laboratory Assessment of the efficacy of Eucalyptus leaf and stem powders in the control of *Callosobruchus maculatus* (Fab.) on stored cowpea. *Samaru Journal of Agricultural Research*. Vol. 13, 1996.

Ekeh, N.F., Onah I.E., Atama, C. I., Ivoke, N., and Eyo, J.E. (2013). Effectiveness of Botanical Powders Against *Callosobruchus maculatus* (Coleoptera: Bruchidae) in Some Stored Leguminous Grains Under Laboratory Conditions. *African Journal of Biotechnology* Vol. 12(12), pp. 1384-1391

Esang, D. M., Madina, P., and Ahmed, J. (2022) Efficacy of Plants Extract in the Control of Cowpea Weevils (*Collosobranchus maculatus*) in Storage at Gombe and Makurdi, Nigeria. Direct Research Journal of Agriculture and Food Science: Vol. 10(2), Pp. 52-58, February 2022.

Ewete, M. C. P., Mantaring, J. B. V. amd David, G. Z. (1996). A Doubleblind, Randomised Controlled Trial on the Use of Malunggay (*Moringa oleifera*) for Augmentation of the Volume of Breastmilk Among Non-nursing Mothers of Preterm Infants. *Philippine Journal of Pediatrics*. 49:3-6.

FAO (2006). Food and Agriculture Organization, The State of Food Insecurity in the World

Golob, P., Moss, C., Devereau, A., Goodland, A. D., Andan, F. H., Atarigya, J. and Tran, B. M. D., (1999). Improvements in the Storage and Marketing Quality of Grain Legumes:Final Technical Report, NRI Report 2417, Project R 6503. Natural Resources Institute University of Greenwich Chatham Maritime Kent, UK. 51 pp.

Gbaye, O.A., Millard, J.C. and Holloway, G.J. (2012).Synergistic Effects of Geographical Strain, Temperature and Larval Food on Insecticide Tolerance in *Callosobruchus maculatus* (F.). *Journal of Applied Entomology* 136:282-291.

IITA. (2009). *Cowpea Crop* [online]. International Institute of Tropical Agriculture, Ibadan, Nigeria. Available from: http://www.iita.org/cowpea [Accessed 16th July, 2017]

Ileke and Bulus., (2012). Response of Lesser Grain Borer, *Rhizopertha dominica* (Fabr.) (Coleoptera: Bostrichidae) to Powders and Extracts of *Azadirachta indica* and *Piper guineense* grains. *Jordan Journal of Biological Sciences*, 5(4):315 – 320

Ileke, K. D. and Oni, M. O., (2011). Toxicity of Some Plant Powders to Maize Weevil, *Sitophilus zeamais* (motschulsky) [Coleoptera:Curculiondae] on Stored Wheat Grains (*Triticum aestivum*) *African Journal of Agricultural Research* Vol. 6(13), pp. 3043-3048,

Ilesanmi, J. O. and T. D. Gungula. (2010). Preservation of Cowpea (*Vigna unguiculata* (L.) *Journal of Stored Products Research* 41, 47-55.

Kaita, H.T., Nukenine, E.N., Stähler, M. and Adler, C. (2010). Insecticidal Efficacy of *Azadirachta indica* Powders from Sun and Shade-dried Grains Against *Sitophilus zeamais* and *Callosobruchus maculates*. *Journal of Entomology and Zoology Studies*, 3 (1): 100-108.

Korunic, S.K., (1996). Effect of Grain Moisture Content and Storage Time on Efficacy of Inert and Botanical Dusts for the Control of *Sitophilus zeamais* in Stored Maize. *Journal of Stored Products and Postharvest Research*, 3(10): 14-151

Latunde-Dada, A.O., R.J. O'Connell, P. Bowyer, and J.A. Lucas. (1999). Cultivar resistance to anthracnose disease of cowpea caused by *Colletotrichum destructivum* O'Gara. European *Journal of Plant Pathology* 105: 445–450.

Massiwa, H.P.S. (2004). Nutrients and antiquality factors in different morphological parts of the *Moringa oleifera* tree. *Journal of Agricultural Science*, Cambridge 128: 311-322

Madina, P. and Akinyemi, B. K. (2023) Effectiveness of solutions on soilless production of lettuce grown in Plateau and Makurdi, Nigeria. Advances in Social Sciences and Management November 2023, Vol-1, No-11, pp. 18-24

Madina P, Michael O. A. and Iyough, D. D (2022**)** Productivity of cabbage (Brassica oleracea L.) as affected by organic manure and varieties grown in Jos Plateau State, Nigeria. Journal of Agricultural Science and Food Technology Vol. 9 (1), pp. 1-5, January 2023

Mathur, S. (2013). Biopesticidal Activity of *Azadirachta indica* A Juss. *Research Journal of Pharmacy, Biology and Chemical Science*, 4(2): 1131-1136

Mordue, A. J, Simmonds, M.S.J., Ley, S.V., Blaney, W.M., Mordue, W., Nasiruddin, M. And Nisbet, A.J. (1993). Actions of azadirachtin, a Plant Allelochemical, Against Insects. *Journal of Insect Physiology*, 11(39): 903-924.

Mitchell, (2009). Consumption of Dry Beans, Peas, and Lentils Could Improve Diet Quality in the US Population. *J Am Diet Assoc*, 2009. 109(5): p. 909-13

Oparaeke, A.M. and Dike I. C., (2002). Evaluation of Comparative Efficacy of some Plant Powders for the Control of *Callosbruchus maculatus* (F) (Coleoptera: Bruchidae) on Stored Cowpea. M.Sc. Thesis, Ahmadu Bello University, Zaria, 105 pp

Oyeyinka E. A., Ogbaji M. I. and Osuman, D. (2013). Insecticidal Actions of the Some Botanicals on Storage Bruchid, (*Callosobruchus maculatus*) of Stored Cowpea (*Vigna unguiculata*). Makurdi, Nigeria. *Journal of Tropical Agriculture, Food, Environment and Extention. Vol. 10 (2): 29-34.*

Oyeniyi E.A., Gbaye O.A. and Holloway G.J. (2015) . Interactive Effect of Cowpea Variety, Dose and Exposure Time on Bruchid Tolerance to Botanical Pesticides. *African Crop Science Journal*, Vol. 23, No. 2, pp. 165 - 175

Quarles, W., (1992) Diatomaceous earth for pest control IPM Practitioner 14 *(5/6):* 1 - 11

Quarles W. and Winn, P. (1996). Diatomaceous Earth and Stored Product Pests IPM Practitioner 18 *(5/6): 1-10*

Salifu, S. W., (2012). Moisture Content: its Significance and Measurement in Stored Products. *Journal of Stored Products Research.* 3: 35-47

Schmutterer, H. (1990). Properties and potential of natural pesticides from the neem tree, *Azadirachta inidica*. *Annual Review of Entomology*; 35: 271–297

Singh, N. and Jackai, K. (1985). Antioxidant properties of various solvent extracts of total phenolic constituents from three different agro-climatic origins of drumstick tree (*Moringa oleifera* Lam.). Journal of Agriculture and Food Chemistry 15: 2144–2155.

Singh, N., Verma, K.V., Saxena, P. and Singh, R. (2000). Anti-Ulcer and Antioxidant Activity of Moringa Oleifera (Lam) Leaves against Aspirin and Ethanol Induced Gastric Ulcer in Rats. *International Research Journal of Pharmaceuticals* 02: 46-57