The Effect of Concentration Rate and Variety on the Mortality of Weevils (Callosobruchus maculatus) in stored Cowpea at Makurdi, Benue State, Nigeria

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Abstract
The 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 objective of this project was to examine the effect of plants extracts, Neem leaf powder on cowpea weevils as an alternative for preserving cowpea at storage at Makurdi. 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. Neem plant powder was used against two cowpea cultivars. The experiment contains 24 treatments, the powders weighing 5g were used against 100g cowpea seeds and the untreated control. 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 where 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 concentration, 3.0g 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 sampea11 in germination percentage on plant extracts the use of 3.0g is superior in all the parameters measured except in seed weight lost. Therefore, the use of 3.0g 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, Concentration, Control, and Bruchid*

Introduction

Cowpea , Vigna unguiculata (L.) walp (Leguminosae) is a tropical, herbaceous annual crop, known by various names in different parts of the world including the black-eye pea, black-eyed bean, china pea, kaffir-pea and marble pea (Purseglove, 1974). While in Nigeria, it is known by Hausas, Yorubas and Ibos as wake, Ewa and Agwa respectively. Cowpea is an important protein source in the diet of most people in the third world countries. In Nigeria, cowpea is more relished than other grains and in the western region of the country constitutes up to 60 percent protein uptake (Oparaeke, 1997). The grain is consumed in various forms either cooked as porridge or in combination with rice, yam or it is ground and fried as cake (akara) or steamed as moi-moi. The green seeds and immature pods are eaten fresh or may be frozen or canned, but are less important in Africa because of shorter storage life. The dry seeds are much more appreciated for their long storage life, good nutritional properties (crude protein 23-25%; carbohydrate 55-60%; fibre 3.9%; ash 3.6% and fat 1.3%), relative ease of storage and preparation for consumption. However, throughout tropical Africa, C. maculatus causes substantial losses of cowpea in storage annually (IITA, 1989).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). The use of botanical insecticides in crop protection is probably as old as crop protection itself (Thacker, 2002). Indeed, prior to the development and commercial success of synthetic insecticides beginning in the 1940s, botanical insecticides were major weapons in the farmer's arsenal against crop pests. In Africa, extracts from locally available plants used alone or in combinations have been traditionally used as crop protectants. Despite the fact that, traders and farmers are aware of the vital need to preserve their produce for the period of scarcity but probably are ignorant of the damage they may cause to mankind by using unauthorized chemicals for grain storage. The use of natural plant products as bio-pesticides to control pests of stored produce has become necessary as an alternative to synthetic insecticides which though effective are expensive and may be toxic to mammals and cause pollution to the environment. Number of improved varieties have been developed by the International Institute of Tropical Agriculture (IITA), combining diverse plant types with resistance or tolerance to several diseases, insect pests, and parasitic weeds and possessing other good agronomic traits (Chikoye, 2010). The varieties IT89KD-288 and IT89KD-391 which were developed by scientists working at Institute for Agricultural Research (IAR) of Ahmadu Bello University, Zaria in collaboration with International Institute for Tropical Agriculture (IITA) Ibadan, and the Agricultural Development Programs (ADPs) of Borno, Kaduna, Kano, and Katisina States have proven to be superior over the current improved lines being cultivated. They could be used to overcome the challenges faced by cowpea farmers in the country. For instance, IT89KD-288 (SAMPEA-11) is a dual–purpose cowpea variety with large white seeds and a rough seed coat. It has combined resistance to major diseases including Septoria leaf spot, and bacterial blight, as well as 24 nematodes and tolerance for Nigeria‟s strain of Striga gesnerioides (a parasitic weed that severely lowers yield). "It also has a yield advantage of at least 80% over the local varieties" (Kamara, 2010).

The nematode resistant variety is an equally good variety for sowing with cereals or as a relay crop with maize in the moist and humid savanna zones, and for high grain production in the dry season. Scientists recommend that the variety be planted in mid-July in the Sudan savanna, early to mid- august in the northern guinea savanna, and by the end of August in the southern Guinea savanna. However, if there is certainty of rains up till the end of October, 1T89KD-288 can be planted in September. 1T89KD-391 (now SAMPEA-12) is also a dual-purpose cowpea variety but it has medium –to- large brown seeds with a rough seed coat. These are preferred seed characteristics for commercial production in northeast Nigeria. 1T89KD-391 is a welcome improvement over SAMPEA 7, Ife brown, IT90K-76 and IT90K-82-2 which are the main improved brown-seeded varieties available. It has been tested extensively in this area and is well accepted by the farmers. It performs well as sole crop and could also be planted as a relay crop with maize in the guinea savanna (Hakeen, 2010).
Neem is known for its “bitter taste” due to the principal active ingredient azadirachtin, which is the most active ingredient. It possesses anti-feedant, 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). Essential oils extracted from neem have insecticidal activies against storage pests (Palacio et al., 2009). Many of these oils have also shown high oviposition and growth inhibitory activies (Tripathi et al., 2000). Volatile compound diallyl disulphid isolated from neem have shown potent toxic, fumigant and feeding deterrent activies against stored grain pests, such as S.oryzae and Tribolium castaneum (Koul, 2004). Volatile constituent, di-n-propyl disulfide extracted from grains of A. indica is toxic, when applied as a fumigant to T. castaneum adults and larvae and S. oryzae adults. Di-n propyl disulfide significantly decreased the growth rate and dietary utilization with moderate inhibition of food consumption in both insects and this component is a potent toxic, fumigant and also act as feeding deterrent to stored grain pests (Abd El-Aziz and E- Shadia, 2001).
Despite the array uses to which plant powders are put to, scanty literature is available on the use of plant powder to preserve the grain. Hence, this study is intended to evaluate the efficacy and dosages of plant powders that can be used by farmers and traders to curtail cowpea wastages. Objectives of the Study is to determine the effect of plant powder (Neem) on mortality of C. maculatus and to ascertain the appropriate dosages of plant powders powder required for effective control of C. maculatus on Stored cowpea.

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. neem plant powder was used against two cowpea cultivars. The experiment contains 24 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 (WhatmanNo.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 concentration on bruchid mortality and population progenies

	Bruchid Mortality (%)				**Population of Progenies**		
Variety	**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
Concentration (g)							
1.0	22.22	48.30	73.30	77.40	12.00	10.60	27.90
2.0	23.61	49.00	77.40	81.60	7.60	11.80	16.90
3.0	29.17	70.50	86.80	91.00	5.60	5.30	8.80
Control	4.17	9.70	16.00	19.60	37.70	36.20	85.70
F-LSD (0.05)	3.29	7.90	8.28	8.22	6.96	7.30	28.36
p-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

F-LSD= Fisher's Least Significant Differences at 5% Level of Probability, HAE= Hours after exposure, WAE= Weeks after exposure.

The data presented in Table 1 explores the main effects of cowpea variety and concentration on bruchid mortality and the population of progenies at different time points after exposure. Bruchid mortality reflects the percentage of bruchids (insects) that have succumbed to the treatment, while the population of progenies indicates the number of offspring produced.

Cowpea Variety Effects: Bruchid mortality varies significantly between the two cowpea varieties (SAMPEA11 and SAMPEA12). SAMPEA12 consistently exhibits lower mortality rates across all time points (24, 72, 120, and 168 hours after exposure - HAE) compared to SAMPEA11. This suggests that SAMPEA12 has higher resistance or tolerance to bruchid infestation. The population of progenies also varies between the cowpea varieties. SAMPEA12 tends to have lower progeny populations compared to SAMPEA11, indicating its potential as a more resistant or less favorable host for bruchid reproduction Koul (2004)

Concentration Effects: Bruchid mortality increases with higher concentrations of the treatment. As the concentration of the treatment (1.0, 2.0, and 3.0 g) increases, the percentage of bruchid mortality generally rises. This concentration-dependent effect suggests that higher concentrations of the treatment lead to increased insect mortality as reported by Ekeh at al., (2013). The population of progenies follows a similar trend, with higher concentrations resulting in lower progeny populations. This indicates that the treatment not only affects the mortality of bruchids but also influences their reproductive success, leading to fewer offspring, this finding collaborate with the work of Al-Maojel (2004) who stated that increase in need dosage affect insect mortality. The data suggests that SAMPEA12 and higher concentrations of the treatment contribute to increased bruchid mortality and reduced progeny populations. These findings have implications for pest management strategies in cowpea cultivation, emphasizing the importance of selecting resistant varieties and utilizing effective concentrations to control bruchid infestation Iyough et al., (2024)

Table 2: Main effects of cowpea variety and concentration 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	0.25	0.004	0.710	<0.001
Concentration (g)							
1.0	11.67	25.50	12.00	1.78	5.22	13.61	6.80
2.0	9.06	23.70	7.60	1.17	3.00	5.94	6.88
3.0	6.11	15.20	5.60	1.06	1.89	4.83	6.97
Control	32.11	61.80	37.70	6.67	22.83	49.56	7.07
F-LSD (0.05)	4.25	7.35	8.48	0.96	2.42	4.01	0.07
p-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<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

This study investigates the main effects of cowpea variety and concentration on key seed parameters, including the number of seeds perforated, seed weight loss, and increase in seed moisture content. Two cowpea varieties, SAMPEA11 and SAMPEA12, were exposed to different concentrations of powder (1.0, 2.0, and 3.0 g) over various time points (4, 8, and 12 weeks after exposure - WAE). The results reveal significant variations in seed responses to the treatments.

Cowpea Variety Effects: SAMPEA12 consistently demonstrates slightly lower values in the number of seeds perforated and seed weight loss compared to SAMPEA11 across the WAE time points. However, the increase in seed moisture content (ISMC) shows comparable values

between the two varieties, this could be related to seed genetic make-up as reported byKamara (2010).
Concentration Effects: The concentration of the powder treatment significantly influences seed parameters. As the concentration increases, the number of seeds perforated and seed weight loss generally decrease, indicating a concentration-dependent protective effect. Conversely, the ISMC tends to increase with higher concentrations, suggesting a potential trade-off between protection and moisture absorption, this work agrees with the work ofChikoye (2010). who reported same trend when concentration was increased in moringa seed powder.
These findings underscore the importance of considering both cowpea variety and treatment concentration in devising effective strategies for seed protection against perforation, weight loss, and moisture absorption. The observed concentration-dependent effects emphasize the need for a balanced approach that considers both pest control and seed quality, Madina et al., 2023

Table 3: Main effects of cowpea variety and concentration 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
Concentration (g)						
1.0	20.00	90.56	90.83	4.88	2.82	603.00
2.0	18.06	91.94	93.06	5.06	2.84	729.00
3.0	19.20	91.67	92.22	5.15	3.18	765.00
Control	6.07	63.33	66.67	3.84	2.62	428.00
F-LSD (0.05)	NS	4.34	4.34	0.81	NS	95.98
p-value	0.082	<0.001	<0.001	0.007	0.061	<0.001

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

Table 3 presents the main effects of cowpea variety and concentration on germination count and seedling vigour at different days after planting (DAP), including root length, shoot length, and overall vigour.Cowpea Variety Effects: Germination counts for SAMPEA11 is significantly higher at 3 DAP compared to SAMPEA12, indicating faster initial germination for SAMPEA11. However, SAMPEA12 exhibits substantially higher germination percentages at 4 and 5 DAP. On the other hand, SAMPEA11 generally outperforms SAMPEA12 in terms of seedling vigour, with higher root length, shoot length, and overall vigour. This could be related to seed viability linked with heredity traits as reported by Musa and Adetunji, (1999).

Concentration Effects: The concentration of the treatment significantly influences germination count and seedling vigour. Higher concentrations (2.0 and 3.0 g) consistently result in higher germination percentages compared to lower concentrations (1.0 g), indicating a concentration-dependent positive effect on germination, the least recorded in control in all the parameters.

Seedling vigour, as measured by root length, shoot length, and overall vigour, also tends to increase with higher concentrations, emphasizing the positive impact of the treatment on seedling development, this could be as result of higher concentration inhibiting seed perforation and giving it a higher chance of seed to seedling growth as reported by IITA. (2009).these findings suggest that both cowpea variety and treatment concentration significantly influence early-stage development in cowpea plants. SAMPEA11 exhibits better germination at the early stages, while SAMPEA12 shows enhanced germination at later stages. Higher concentrations of the treatment generally lead to improved germination and seedling vigour. These results have implications for optimizing seed treatment strategies to enhance cowpea germination and seedling growth, Iyough et al,. (2024)

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

		Brucid mortality (%)				**Population of progenies**		
Variety	**Concentration**	24 HAE	72 HAE	120 HAE	168 HAE	4 WAE	8 WAE	12 WAE
SAMPEA 11	1.0	30.56	58.30	77.80	81.90	11.60	5.10	16.80
	2.0	29.17	61.10	83.30	87.50	10.10	12.00	16.60
	3.0	36.11	79.90	90.30	94.40	6.40	4.30	11.90
	Control	6.25	11.80	20.10	26.00	43.40	38.60	50.20
SAMPEA 12	1.0	13.89	38.20	68.80	72.90	12.40	16.00	39.10
	2.0	18.06	36.80	71.50	75.70	5.00	11.70	17.30
	3.0	22.22	61.10	83.30	87.50	4.80	6.20	5.70
	Control	2.08	7.60	11.80	13.20	32.00	33.90	121.10
	F-LSD (0.05)	4.65	NS	NS	NS	NS	NS	40.10
	P-value	0.003	0.071	0.946	0.886	0.323	0.168	0.038

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 study explores the interaction effect of cowpea variety and treatment concentration on bruchid mortality and the population of progenies, providing insights into the efficacy of pest control measures. Two cowpea varieties, SAMPEA11 and SAMPEA12, were subjected to different concentrations of a treatment (1.0, 2.0, 3.0 g and control), with observations recorded at various time points after exposure (24, 72, 120, and 168 hours after exposure - HAE, and 4, 8, and 12 weeks after exposure - WAE).

Bruchid Mortality: SAMPEA11 demonstrates a concentration-dependent increase in bruchid mortality, with higher concentrations leading to elevated mortality percentages at all HAE time points. Conversely, SAMPEA12 shows more variable responses, with the highest mortality observed at 3.0 g concentration, this could be attributed to the fact high concentration may inhibit the insect activities and coused mortality as reported by Kamara 2010

Population of Progenies:The population of bruchid progenies generally decreases with increasing concentration for both varieties. SAMPEA11 exhibits a notable decrease in progeny population as the concentration increases, while SAMPEA12 shows a similar trend with varying responses this result is a per with the finding of Hakeem (2010) who reported same trend.

Interaction Effect: Statistical analysis using Fisher's Least Significant Differences (F-LSD) reveals significant differences in bruchid mortality and progeny populations, particularly at 1.0 g concentration. The interaction effect highlights the importance of considering both variety and concentration in developing effective pest management strategies this result is a par with the finding of FAO (2006) who same trend. The study underscores the complexity of the interaction between cowpea variety and treatment concentration on bruchid infestation dynamics. While SAMPEA11 tends to respond more consistently to higher concentrations, SAMPEA12 shows varying responses, emphasizing the need for tailored approaches based on specific cowpea varieties, Nater (2022)

These findings contribute to the understanding of integrated pest management in cowpea cultivation, emphasizing the importance of considering both cowpea variety and treatment concentration to optimize the efficacy of pest control measures Ghasi et al., (2000)

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

		Number of seeds perforated			**Seed weight loss (%)**			
Variety	**Concentration**	4WAE	8WAE	12WAE	4WAE	8WAE	12WAE	CSMC (%)
SAMPEA 11	1.0	11.22	20.70	30.90	1.89	5.44	12.22	6.92
	2.0	11.00	26.80	37.60	1.56	3.22	5.44	7.04
	3.0	6.11	17.40	24.40	0.89	2.00	7.33	7.20
	Control	29.11	62.30	74.70	7.11	27.4	50.00	7.12
SAMPEA 12	1.0	12.11	30.30	53.60	1.67	5.00	15.00	6.68
	2.0	7.11	20.70	34.20	0.78	2.78	6.44	6.72
	3.0	6.11	12.90	20.10	1.22	1.78	2.33	6.73
	Control	35.11	61.20	84.20	6.22	18.22	49.11	7.01
	F-LSD (0.05)	NS	NS	11.99	NS	3.43	NS	0.10
	P-value	0.150	0.143	0.007	0.557	<0.001	0.255	<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
CSMC= Change in seed moisture content
NS= Not significant

This study investigates the interaction effect of cowpea variety and treatment concentration on bruchid-induced damage and seed moisture content, providing insights into the impact of pest management strategies on seed quality. Two cowpea varieties, SAMPEA11 and SAMPEA12, were exposed to different concentrations of a treatment (1.0, 2.0, 3.0 g and control), and observations were recorded at 4, 8, and 12 weeks after exposure (WAE).
On Bruchid-Induced Damage: SAMPEA11 exhibits a concentration-dependent reduction in the number of perforated seeds and seed weight loss, with the lowest values observed at 3.0 g concentration. SAMPEA12 also demonstrates reduced damage at higher concentrations, albeit with varying responses. On seed moisture content: Change in seed moisture content (CSMC) follows asimilar trend, with both varieties showing a concentration-dependent decrease in CSMC. SAMPEA11 consistently displays lower CSMC values across all concentrations, indicating a potential correlation between reduced bruchid damage and lower seed moisture content, this result is similar with the finding of Kamara (2010) Who stated that higher concentration affect or bring about seed changes moisture content.
Interaction Effect: Statistical analysis using Fisher's Least Significant Differences (F-LSD) indicates significant differences in bruchid-induced damage and CSMC, particularly at 3.0 g concentration. The interaction effect underscores the importance of considering both cowpea variety and treatment concentration in optimizing seed quality, as reported by El-Jasser (2011). who reported that higher concentration of plant extracts and plant genetic make-up lead to seed quality and early plant establishment. The study highlights the potential of higher treatment concentrations in minimizing bruchid-induced damage and preserving seed moisture content. SAMPEA11 generally exhibits a more pronounced response to higher concentrations compared to SAMPEA12. The findings emphasize the importance of tailored pest management strategies to maintain seed quality and reduce post-harvest losses, Madina at al., (2022)
These results contribute valuable insights for developing effective and sustainable pest control measures in cowpea cultivation, considering both the specific variety and treatment concentration. Further research is recommended to explore the underlying mechanisms and to refine treatment strategies for enhanced seed quality in cowpea productionDejen (2002)

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

		Germination count (%)			**Seedlings**		
Variety	**Concentration**	3 DAP	4DAP	5DAP	Root length	Shoot length	Vigour
SAMPEA 11	1.0	39.40	88.33	88.33	5.99	3.16	803.00
	2.0	37.20	91.11	91.11	6.32	3.25	865.00
	3.0	38.30	91.67	92.22	6.53	3.87	953.00
	Control	13.30	53.33	60.00	4.33	3.00	447.00
SAMPEA 12	1.0	0.60	92.78	93.33	3.76	2.49	583.00
	2.0	0.00	92.78	95.00	3.80	2.44	593.00

3.0	0.00	91.67	92.22	3.76	2.48	577.00
Control	0.00	73.33	73.33	3.35	2.48	410.00
F-LSD (0.05)	NS	NS	NS	NS	NS	NS
P-value	0.090	0.002	0.026	0.136	0.264	0.008

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

This table presents data on the interaction effect of variety and concentration on cowpea seed germination and seedling vigor. Varieties: Two varieties are considered: SAMPEA 11 and SAMPEA 12. And Concentration: Three concentrations are tested: 1.0, 2.0, and 3.0 and control, the Parameters measured are Germination count (%) at 3, 4, and 5 days after planting (DAP), Seedlings' root length, shoot length, and overall vigor. The result shows SAMPEA 11: Germination percentages generally increase with higher concentrations. Shoot and root lengths also tend to increase with concentration. Vigor shows an increasing trend with concentration. The Control group has lower values in all parameters. SAMPEA 12: Germination percentages are generally high and not significantly affected by concentration. Shoot and root lengths show less variability with concentration compared to SAMPEA 11 as reported by Atser (2010). Vigor also shows less variability while Control group has lower values in all parameters. The result shows variety and concentration both influence germination and seedling vigor, and SAMPEA 12 appears to have higher overall germination percentages compared to SAMPEA 11. Concentrations generally affect SAMPEA 11 more than SAMPEA 12. While control group consistently has lower values in all parameters measured, these table provides insights into the interactive effects of variety and concentration on cowpea seed germination and seedling vigor, offering valuable information for agricultural research or practices, Abraham and Basedow (2005).

Conclusion

From the finding in this work, therefore, it is evidence that the use of 3.0g of neem seeds 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.

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