



Comparative Efficacy of *Jatropha curcas* L. Seed Powder for the Control of *Callosobruchus subinnotatus* (Pic) on Stored Bambaranut, *Vigna subterranea* (L.) Verdcourt

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Abstract

The study was to assess insecticidal effectiveness of *Jatropha curcas* L. seed powder on *Callosobruchus subinnotatus* (Pic) infesting stored bambaranut, *Vigna subterranea* (L.) Verdcourt. The experiment was laid out in a factorial design of 4×2 levels (seed powder at the rates of 0.0, 0.5, 1.0 and 1.5 g, with and without addition of the synthetic insecticide at 0.01 g/20 g bambaranut seed) and laid out in a completely randomized design, in three replicates. Results obtained showed lowest oviposition, progeny emergence and seed damage (5.33, 1.58 and 1.83, respectively) in bambaranut seeds admixed with 1.0 g of the seed. Although, statistically similar to all other treatments, it was significantly ($P \leq 0.001$) better than the control treatment in which 33.83 eggs were laid and 24.08 adults emerged from 22.92 emergence holes. In addition, at six (6) days after treatment, highest adult mortality rate (99.17%) similar to that (99.17%) obtained in the synthetic insecticide was also recorded in seeds treated with 1.0 g seed powder. However, all other treatments were also significantly better than the control, in which 72.50% of the introduced bruchids died. Comparatively, lowest rate of seed damage (6.68%) and lasting effect was also obtained with the addition 1.0 g seed powder. In conclusion, appreciable level of protection on bambaranut seeds was achieved using seed powder of *J. curcas*. Therefore, it is recommended that for effective management of *C. subinnotatus* infesting bambaranut, farmers could use 5 Kg seed powder on 100 Kg bambaranut seeds.

Keywords: *Callosobruchus subinnotatus*, bambaranut, *Jatropha curcas*, damage, Oviposition.

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INTRODUCTION

An underutilized legume, bambaranut, *Vigna subterranea* L. (Verdcourt) was once the third most important grain legume after peanut and cowpea. Mainly grown by women for the sustenance of their families, bambaranut was cultivated in extreme tropical environments by peasant farmers who lacked access to irrigation and/or fertilizers and with little guidance on improved practices (Mukurumbira, 1985; Mwale *et al.*, 2007). In addition to human consumption and fodder for livestock, bambaranut is used in traditional medicines as a remedy for many ailments in humans and livestock, which include *helminthosis*, *schistosomiasis*, leprosy, diarrhoea and *psoriasis* (Burkill, 1995). However, in spite of its usefulness and nutritional values, bambaranut, is reported to be threatened by the devastating activities of stored products pests, notably the bambaranut bruchid, *Callosobruchus subinnotatus* Pic. (Lale and Vidal, 2003).

Although, success has been recorded with the use of synthetic insecticides, abuse and inappropriate use of the synthetic insecticides have caused a lot of problems ranging from high costs to mammalian toxicity (Dike and Mshelia, 1997). In addition, the use of synthetic chemical insecticides reduced viability of seeds (Bamaiyi *et al.*, 2007). These serious limitations posed by the use of synthetic insecticides as preservatives during storage on one hand and losses caused by *C. subinnotatus* during storage on the other have called for search of a new alternative method of controlling the pest. Recently, particular interest has been focused on the use of natural plant products because they are available locally, cheap, less hazardous and environmentally friendly as well as safe and easy to handle. Moreover, botanical

pesticides are biodegradable thereby leaving no residual toxicity to man. However, little information exists on the insecticidal properties of the physic nut, *Jatropha curcas* L. (Euphorbiaceae) for the control of *C. subinnotatus* in stored bambaranut.

MATERIALS AND METHODS

Preparation of Bambaranut Seeds

Fifty kilogrammes of unshelled bambaranut, cream/brown eye variety seeds were purchased at a local market in Dambatta Local Government Area, Kano State, Nigeria. The seeds were decorticated manually. Shrivelled (shrunken) and damaged seeds as well as all other debris were removed. To disinfest the cleaned whole seeds, they were put in a polythene bag together with two phostoxin tablets (in an envelope) for 24 hours. The mouth of the bag was tied securely to ensure that any insect pest present within the seeds was killed according to the method of Ogunwolu *et al.*, (2002). Thereafter, the seeds were opened and spread in a shaded well ventilated place for 48 hours to ensure that the seeds were free from the phostoxin residue. To avoid subsequent re-infestation, the previously fumigated seeds were transferred into a fresh and different polythene bag and kept at -4°C inside a fridge for four days following the method of Ahmed (2007).

Collection and preparation of the *Jatropha curcas* seeds

The seeds of the physic nut, *J. curcas* were collected at the orchards of Audu Bako College of Agriculture, Dambatta, Kano State, while the Actellic dust was purchased from a pesticide store at Abubakar Rimi market, Sabon-gari, Kano, Kano State, Nigeria.

The seeds were dried in shade to crispy condition. Thereafter, it was pounded in a mortar with pestle and then passed through 40 µm sieve to give a very fine powder as described by Youdeowei (2004) and Yusuf and Ahmed (2005). The fine powdered plant material was kept in plastic bag until needed.

Source and Rearing of Insect Culture

The initial culture of the bambaranut bruchids was obtained from naturally infested bambaranut seeds at Kurmi Market, Kano City, Kano State, Nigeria. A sample of the insects on infested seeds was taken to the Department of Crop Protection, Ahmadu Bello University, Zaria, Kaduna State, Nigeria for proper taxonomic identification as *Callosobruchus subinnotatus* (Pic.). These were then reared in transparent plastic buckets measuring 30 cm in height and 15 cm top diameter. The top end of the plastic buckets was covered with white muslin cloth, secured firmly into place with rubber bands, hence allowing for ventilation. These were incubated in Kilner jar at an ambient temperature and relative humidity ($32\pm 3^{\circ}\text{C}$ and $57\pm 3\%$, respectively) with alternating light and dark cycle for 12 hours as previously described by Abduljalal *et al.* (2011).

Experiment and Experimental Design

The experiment was conducted in the Crop Protection Laboratory I, Faculty of Agriculture, Bayero University, Kano State ($11^{\circ}59'47''\text{N}$, $8^{\circ}31'0''\text{E}$) (Kowal and Knabe, 1972); to assess the effect of the *J. curcas* seed powder on biocide (adult mortality) and damage (number of eggs, adult emergence and holes as well as percentage seed damage, seed weight lost and germination) caused by *C. subinnotatus* on bambaranut. The experiment was set up in a 4×2 factorial experiment with the first factor (seed powder

of *J. curcas*) having four (4) levels (0, 0.5, 1.0 and 1.5 g/20 g seed) while the second factor (pirimiphos-methyl) had two levels (with and without) applied at reduced standard rate of 0.01 g/20 g (Gwinner, *et al.*, 1996). There were eight (8) treatments replicated three (3) times in a completely randomized design. The treatments were admixed with the bambaranut and shaken vigorously after which, five pairs of day-old adult *C. subinnotatus* were introduced into each treatment in plastic cups measuring 10 cm in depth and 9 cm top diameter; and were kept in the laboratory at ambient temperature and relative humidity of $32\pm 3^{\circ}\text{C}$ and $57\pm 3\%$, respectively. The top of the plastic cups were covered with white muslin cloth held in place with rubber bands to secure it firmly and to prevent insect escape.

Assessment of the Potentials of the Plant Products Number of eggs laid

The number of eggs laid was counted with the aid of hand lens at 14 days after treatment (DAT) (Aliyu and Ahmed, 2006) when all the introduced adult insects were dead and those that were still living removed (Appleby and Credland, 2001).

Number of Adult Emergence

Considering the period of emergence from egg to adult as 34-42 days after oviposition Mbata (1992), when all the eggs laid were hatched, the number of adult emergence was taken as the total number of adults that emerged. Adult *C. subinnotatus* that emerged were removed and recorded daily in all the treatments and replicates and their cumulative numbers were considered as F_1 generation emergence.

Number of emergence holes

Number of emergence (exit) holes was assessed by counting the number of holes

that appeared on each seed. This was conducted with the aid of a needle, which was used to standardize the holes in such a way that no hole was counted more than once. The seeds were turned upside down and from side to side to ensure that no holes were left uncounted as described by Aliyu and Ahmed (2006) and Abduljalal *et al.* (2011).

Adult mortality

Assessment of adult mortality was carried out from the first day after treatment (DAT) and continued subsequently until all insects were dead by counting the number of insects that died daily as a result of the treatment applied as described by Lale and Yusuf (2001); and Yusuf and Ahmed (2007). Percent adult mortality was determined as the number of dead insects divided by the total number of insects introduced, multiplied by 100.

% Adult mortality

$$= \frac{\text{Number of dead insects}}{\text{Total number of insects introduced}} \times 100$$

Data on percentage adult mortality was corrected using Abbot's (1925) formula.

$$Pr = \frac{Po - Pc}{1 - 00 - Pc}$$

Where,

Pr = Corrected mortality (%)

Po = Observed mortality (%)

Pc = Control mortality (%)

Percentage seed damage

This parameter was measured as the percentage of the difference between the number of seeds without holes (in each experimental unit) and the number of seeds with holes (in the same experimental unit)

divided by the total number of seeds multiplied by 100 (Ogunwolu *et al.*, 2002).

$$PSD = \frac{NGWH}{TLNG} \times 100$$

Where: PSD = Percentage seed damage;
NGWH = Number of grains with holes;
TLNG = Total number of grains.

Percentage seed weight lost

This parameter was also measured as the percentage of the difference between the initial and final weight of the seeds divided by the initial weight as described by Golob *et al.* (1982)

$$PSWL = \frac{[UaN - (U + D)]}{UaN} \times \frac{100}{1}$$

Where: PSWL = Percentage seed weight loss

U = Weight of unaffected seeds in the sample

N = Total number of seeds in the sample

Ua = Average weight of unaffected seeds

D = Weight of affected seeds in the sample

Potency

Data on residual toxicity (potency of the seed powder) were collected by counting the number of dead insects out of the first generation (F₁) progeny reproduced by the parents which were introduced into the treated seeds 60 days after treatment when all the introduced parents were dead and the offsprings had emerged (Abduljalal *et al.*, 2011).

Data analysis

Data in percentages were transformed into arc sine percentages, while numerical data with low or zero count were transformed using $\sqrt{n+1}$ before analysis, as described by Little (1978). The transformed data was subjected to analysis of variance using

computer software (SAS for windows) statistical package. Treatments with significant differences were compared and separated at 0.05% level of probability using Duncan's multiple range test (DMRT).

RESULTS

Table 1 shows the effects of *Jatropha curcas* seed powder, with and without the synthetic chemical powder, on oviposition, number of progenies and exit holes. In all instances, the treatment rates, with and without addition of the Actellic® dust, and the check treatment were statistically similar but significantly ($p < 0.001$) different from the control. The least number of eggs, bruchids emerged and exit holes (5.33, 1.58 and 1.83, respectively) were obtained with the use of 1.0 g seed powder without the synthetic insecticide and this result was similar to the number of eggs, bruchids emerged and exit holes (5.92, 2.58, and 2.25, respectively) obtained from the synthetic insecticide.

Table 2 shows the effect of the treatment concentrations, with and without Actellic® dust on per cent mortality of the bruchids. Apart from the check, the use of 0.5 g seed powder with synthetic insecticide at 1 and 2 days after treatment (DAT), per cent bruchid mortality in all remaining treatments, with and without Actellic® dust, were statistically similar. In some cases, lower per cent mortality was even obtained in the control. During the same period (1 and 2 DAT), higher per cent bruchid mortality (41.67 and 80.00%, respectively) were obtained with the use of 0.5 g seed powder with synthetic insecticide, and this was significantly ($p < 0.001$) more than the per cent mortality (31.67 and 46.67% at 1 and 2 DAT, respectively) in the control. However, both treatments (0.5 g seeds powder with synthetic insecticide and the control) caused

statistically lower bruchid mortality than the synthetic insecticide, in which 84.17 and 90.00% of the bruchids were killed at 1 and 2 DAT, respectively. However, at 3 DAT, an increase in efficacy was indicated by most of the treatments. Rates of mortality (59.17, 58.33 and 58.33%) recorded in 1.0 and 1.5 g seed powder with synthetic insecticide and 0.5 g seed powder without the synthetic insecticide, respectively were significantly ($p < 0.001$) higher than that (50.83%) obtained in the control. In addition, the rate of mortality (85.00%) obtained using 0.5 g seed powder with synthetic insecticide was similar to that (90.83%) of the synthetic insecticide. Subsequently, at 4, 5 and 6 DAT significant ($p < 0.001$) protection, similar to that obtained in the synthetic insecticide was obtained using all of the treatments, with and without the synthetic insecticide.

In terms of weight loss, there was no significant difference observed among the treatments, with and without synthetic chemical, the check and the control. However, the seeds were least damaged when 1.0 g seed powder without the synthetic chemical was applied and this was similar to results obtained in the check. In addition, seed damage was significantly ($p < 0.01$) lower in all of the treatments compared to the control, as presented in Table 3.

Result in Table 4 shows that strong residual toxic effect, similar to that obtained in the check treatment, was obtained in all of the treatments, with and without the synthetic chemical. Least number (0.08) of live bruchids obtained with the application of 1.0 g seed powder without synthetic chemical, similar to that (0.33) from the check was significantly ($p < 0.001$) different from that (21.33) of the control (Table 4).

Table 1: Effect of *Jatropha curcas* seed powder with and without synthetic insecticide application on oviposition, adult emergence and damage caused by *Callosobruchus subinnotatus* infesting stored bambaranut

Seed powder(g)	Treatment		Oviposition	F ₁ Emergence ^Ω	Damage
	Actelic 2% Dust (g)				
0.0	0.00		33.83 ^{aΩ}	24.08 ^{aΩ} (29.33)	22.92 ^{aΩ}
0.0	0.01		5.92 ^b	2.58 ^b (9.10)	2.25 ^b
0.5	0.00		8.58 ^b	2.92 ^b (9.81)	3.33 ^b
0.5	0.01		7.50 ^b	3.17 ^b (10.14)	5.67 ^b
1.0	0.00		5.33 ^b	1.58 ^b (7.04)	1.83 ^b
1.0	0.01		12.33 ^b	3.08 ^b (9.98)	1.67 ^b
1.5	0.00		11.67 ^b	2.83 ^b (9.63)	4.58 ^b
1.5	0.01		11.50 ^b	2.92 ^b (9.81)	1.92 ^b
	SE±		3.241	1.628	2.397

^ΩMeans within a column followed with different letters are statistically significantly different at *** = P ≤ 0.001, Duncan's multiple range test.

^ΩFigures in parentheses are Arcsine $\sqrt{\text{percentage}}$ transformations.

*L.S = level of significance.

Table 2: Effect of *Jatropha curcas* seed powder with and without synthetic chemical application on per cent adult mortality of *C. subinnotatus* infesting stored bambara nut

Seed powder(g)	Treatment		Days after treatment (DAT)					
	Actelic 2% Dust (g)		1	2	3	4	5	6
0.0	0.00		31.67 ^{cΩ}	46.67 ^{cdΩ}	50.83 ^{dΩ}	61.67 ^{dΩ}	69.17 ^{dΩ}	72.50 ^{cΩ}
0.0	0.01		84.17 ^a	90.00 ^a	90.83 ^a	91.67 ^a	96.67 ^{ab}	99.17 ^a
0.5	0.00		20.00 ^d	49.17 ^c	58.33 ^{bc}	80.00 ^{bc}	88.33 ^c	94.17 ^b
0.5	0.01		41.67 ^b	80.00 ^b	85.00 ^a	87.50 ^{ab}	97.50 ^a	98.33 ^{ab}
1.0	0.00		25.00 ^{cd}	44.17 ^{d-f}	50.33 ^d	90.0 ^a	95.00 ^{a-c}	99.17 ^a
1.0	0.01		24.17 ^{cd}	45.83 ^{c-e}	59.17 ^b	76.67 ^c	90.00 ^{bc}	98.33 ^{ab}
1.5	0.00		27.50 ^{cd}	40.00 ^f	51.67 ^{cd}	80.00 ^{bc}	94.17 ^{a-c}	96.67 ^{ab}
1.5	0.01		28.33 ^c	41.67 ^{ef}	58.33 ^{bc}	91.67 ^a	95.00 ^{a-c}	97.50 ^{ab}
	SE±		2.480	1.415	2.406	2.810	2.287	1.500

^ΩMeans within a column followed by different letters are statistically significantly different at *** = P ≤ 0.001, Duncan's multiple range test.

*L.S = level of significance.

Table 3: Effect of *Jatropha curcas* powder extract with and without synthetic chemical application on per cent seed damage and weight loss caused by *Callosobruchus subinnotatus*

Treatment		Per cent (%)	
Seed powder(g)	Actelic 2% Dust (g)	Seed damage	Seed weight loss
0.0	0.00	27.43 ^{aΩ}	7.35
0.0	0.01	7.90 ^b	3.80
0.5	0.00	11.17 ^b	4.13
0.5	0.01	10.61 ^b	4.26
1.0	0.00	6.68 ^b	4.62
1.0	0.01	14.49 ^b	4.20
1.5	0.00	16.49 ^b	4.51
1.5	0.01	12.23 ^b	4.49
SE±		3.730	1.324

^ΩMeans within a column followed by different letters are statistically significantly different at ** = $P \leq 0.01$ and NS = not significant, Duncan's multiple range test.

*L.S = level of significance

Table 4: Potency effect of *Jatropha curcas* seed powder with and without synthetic chemical application on *Callosobruchus subinnotatus* at 60 DAT

Treatment		Potency [△]
Seed powder(g)	Actelic 2% Dust (g)	
0.0	0.00	21.33 ^{aΩ} (27.49)
0.0	0.01	0.33 ^b (0.99)
0.5	0.00	0.42 ^b (1.15)
0.5	0.01	0.17 ^b (0.57)
1.0	0.00	0.08 ^b (0.00)
1.0	0.01	3.08 ^b (9.98)
1.5	0.00	2.42 ^b (8.91)
1.5	0.01	1.00 ^b (5.74)
SE±		2.024

^ΩMeans within a column followed by different letters are statistically significantly different at *** = $P \leq 0.001$, Duncan's multiple range test.

[△]Figures in parentheses are Arcsine $\sqrt{\text{percentage}}$ transformations.

*L.S = level of significance.

DISCUSSION

Many reports have indicated that many species of herbs and their extracts were known to possess insecticidal activities, which may be present in their extracts (Schmidt *et al.*, (1991). In addition, Brattesten (1983) observed that natural plant products (botanicals) could have an

advantage over synthetic pesticides as they are more cost-effective and environmentally sustainable alternative for protecting stored food against insect attack. However, information and scientific support on botanicals is generally inadequate and it is often difficult to recommend particular plant materials as a replacement for chemical insecticides,

because efficacy levels of botanicals could vary among storage pests, application methods and stored products.

The use of plant extracts as insecticides to protect grains, especially legumes, against storage insects is traditional practice in many countries in Asia and Africa. The method was reported as convenient and inexpensive for the protection of stored seeds in households and on small farms and many different edible plant products have been studied as stored grain protectants (Ahmed *et al.*, 1988; Don-Pedro, 1989; Pacheco *et al.*, 1995).

Kumar and Sharma (2008) stated that oil and other extracts from *J. curcas* can be used as bio-pesticides, due to their insecticidal, molluscicidal, fungicidal, and nematocidal properties. Similarly, Gübitz *et al.* (1999) reported that extracts from *J. curcas* when used as natural crop pesticide in controlling insect pests, could be a promising alternative to hazardous chemicals. The findings of this research also conforms to the findings of Saxena *et al.* (1988); Schmidt *et al.* (1991); Asawalam and Adesiyan (2001) which stated that plant parts; oils, extracts, and powder mixed with grains reduced insect oviposition, egg hatchability, postembryonic development. Also, Obeng-Ofori and Reichmuth, (1997) reported scientific evidence, which proved that plant derivatives inhibit progeny production by causing insect egg mortality. In addition, Heller (1996) reported extracts from *J. curcas* as potential products for controlling several insect pests. The report further added that, unlike spraying with synthetic chemicals, application of *J. curcas* extracts seemed not to affect populations of beneficial arthropods.

CONCLUSION

The plant extract used in this study proved effective and provided substantial reduction of oviposition, progeny emergence and consequently lower number of exit holes

(seed damage). Substantial protection was achieved by using the plant extract singly, which was similar to that provided by using the synthetic insecticide powder (Actellic® dust, 2%). From the findings of this study, it could be recommended that 5 Kg of *Jatropha curcas* seed powder admixed with 100 Kg bambaranut seeds provided the best result for the control of *C. subinnotatus* on bambaranut during storage.

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