Effect of Nano particles against cigarette beetle 
(Lasioderma serricorne Fabricius) in cured turmeric rhizomes (Curcuma longa Linnaeus)

K Ravi Kumar, C Narendra Reddy, K Vijaya Lakshmi, K Rameash, K Keshavulu and B Rajeswari

Abstract
An experiment was conducted to study the effect of different nano particles, viz, Nano silica @ 0.5g kg-1, 0.25g kg-1, 0.175g kg-1 of cured turmeric rhizomes, Nano alumina @ 0.5g kg-1, 0.25g kg-1, 0.175g kg-1 of cured turmeric rhizomes, Nano clay @ 0.5g kg-1, 0.25g kg-1, 0.175g kg-1 of cured turmeric rhizomes and Diatomaceous earth @ 5g kg-1 of cured turmeric rhizomes (check) along with control. All the treatments were replicated thrice. Among the three nanocides, nano silica applied at 0.5 and 0.25 g kg⁻¹ dosages showed the superior performance of the over other treatments at one day after treatment followed by nano silica at 0.175 g kg⁻¹ which caused higher mortality, reduced oviposition and adult emergence of L. serricorne and has a great promise in cigarette beetle pest management.

Keywords: Turmeric, cigarette beetle and nano particles

Introduction
Turmeric is a rhizomatous herbaceous perennial plant belonging to the ginger family (Zingiberaceae), botanically known as Curcuma longa Linnaeus, originated from Tropical south Asia (India) (Ravindran et al., 2007) [11]. It is one of the oldest spices and an important spice bowl of India which had been used since ages. The world production of turmeric stands at around 8, 00,000 tons in which India hold a share of approximately 75 to 80 per cent. India consumes around 80 per cent of its own production (INDIADSTAT.COM- 2015) [7]. In India the total area under cultivation is 184.4 thousand hectares with production of 830.40 thousand metric tonnes and productivity of 4.50 MT Ha⁻¹(INDIADSTAT.COM- 2015) [7]. Among all the states, Telangana state stands first in area with 43.50 thousand hectares and production of 216.30 thousand metric tonnes while Himachal Pradesh stands first in productivity with 17.90 MT Ha⁻¹ (INDIADSTAT.COM- 2015) [7]. Various insects have been recorded on dry turmeric, which belong to the order coleoptera. include cigarette beetle (Lasioderma serricorne Fab.), drugstore beetle (Steigobium panicenum L.), Red flour beetle (Triobolium castaneum Herbst) lesser grain borer (Rhyzopertha dominica Fab.), Saw toothed grain beetle (Oryzaephilus surinamensis L.) and coffee bean weevil (Araecerus fasciculatus DeG.) (Ravindran et al., 2007) [11]. Among all these insects, the cigarette beetle (Lasioderma serricorne Fab.) is serious. The damage loss by cigarette beetle in turmeric in terms of quantitative weight loss at three and six months after storage was recorded as 7.15 and 22.75 per cent in turmeric (Vidya and Awaknavar, 1994) [16]. Cigarette beetle, Lasioderma serricorne (Fabricius) (Coleoptera: Anobiidae) is the most serious pest of high value commodities and stored products. It is a generalist feeder, known to successfully feed, develop and breed on a variety of durable commodities including grain based products, spices, tobacco and dried medicinal herbs (Jacob, 1992) [8]. L. serricorne was known to develop on a variety of grain based products, spices, tobacco and infest these commodities during storage, and manufacturing (Dimetry et al., 2004) [9]. L. serricorne was a major pest found in cured tobacco and cigarette products. It also infests many other stored food products (Hagstrum and Subramanyam, 2009) [6]. Majority of the farmers of the region store the cured and dried turmeric rhizomes and fingers for getting better price. During storage cigarette beetle attacks the produce and cause considerable loss to the farmers. The adult beetle lay eggs on the produce and the grubs spoil the produce and make it powdery resulting in deterioration in quality, reduction of nutritive and medicinal values (Ravindran et al., 2007) [11]. The larvae of cigarette beetle tunnel into dry turmeric and also...
contaminate the produce with abundant production of frass. The grubs and adults also make extensive holes in the produce. The adults of cigarette beetle do not feed but tunnel through the produce to leave the cocoon making extensive holes (Ravindran et al., 2007).

Nanotechnology (sometimes shortened to “nanotech”) is the manipulation of matter at an atomic and molecular scale. Generally, nanotechnology works with materials, devices, and other structures with at least one dimension sized from 1 to 100 nano meters. Thus nanotechnology deals with the targeted nano particles as and when the particles exhibit different physical strength, chemical reactivity, electrical conductance and magnetic properties (Nykypanchuk et al., 2006) [10]. Nano particles hold great promise regarding their application in plant protection due to their size dependent qualities, high surface to volume ratio and unique optical properties. Also, researchers believe that nanotechnology will revolutionize agriculture including pest management in the near future (Bhattacharyya et al., 2010) [11]. Mohamed Ragaei and Al-kazafy (2014) [9] reported that nanotechnology would provide greener and efficient alternatives for the management of insect pests in agriculture without harming the nature.

Nano-technology has become one of the most promising new technologies in the recent decade. Use of inorganic inert dusts is considered as one of the environment friendly alternative to chemical pesticides in stored pest management (Stadler et al., 2012) [15]. They are chemically stable, highly persistent and have low mammalian toxicity. Inert dusts mainly contain synthetic silica (silica dioxide) and natural silica such as diatomaceous earth (DE), kaolinite and silica gel which predominantly consists of amorphous and shapeless silica. They kill the arthropods by removing or adsorbing the epicuticular lipid layers causing excessive water loss through cuticle (Stadler et al., 2012). Diatomaceous earth becomes more effective against insects if it possess high amorphous silica content with uniform size distribution (Korukpin, 1997).

Recently, a novel type of particulate material, nano structured alumina (NSA) has been found to induce mortality on two insect species, rice weevil Sitophilus oryzae (L.), and lesser grain borer Rhizopertha dominica, (F.), major pests of stored grain in milling and processing, food warehouses, and foodstuffs (Stadler et al.,2012) [15]. They are chemically stable, highly persistent and have low mammalian toxicity. Inert dusts mainly contain synthetic silica (silica dioxide) and natural silica such as diatomaceous earth (DE), kaolinite and silica gel which predominantly consists of amorphous and shapeless silica. They kill the arthropods by removing or adsorbing the epicuticular lipid layers causing excessive water loss through cuticle (Stadler et al., 2012). Preliminary studies have found the insecticidal activity of SNP against many pests reported by Ziae and Ganji (2016) [17], Boraei and Nilly (2015) [2], Rouhani et al. (2013) [12], Debnath et al. (2012a) [3] and Stadler et al. (2010) [14].

Since the spice is being widely used for consumption, there is a need to test use of biorational approaches for management of L. serricorne is need of hour.

In view of serious losses in storing the turmeric from the infestation and a search for the possible biorational, the present investigation was taken up.

**Materials and Methods**

Management of cigarette beetle by using the nano particles was carried out at National Bureau of Plant Genetic Resources (NBPGR), Regional Research Station, Rajendranagar, Hyderabad and at laboratory of Department of entomology, Professor Jayashankar Telangana State Agricultural University (PJTSAU), Hyderabad, Telangana During 2014-16.

Management of cigarette beetle by nano particles of silica (10-20 nm), alumina (< 50 nm) and clay (< 100 nm) was tested in turmeric at National Bureau of Plant Genetic Resources (NBPGR), Regional Research Station, Rajendranagar, Hyderabad. Nano silica, nano alumina, nano clay and diatomaceous earth were procured from Sigma Aldrich, USA. Each nano treatment was tested at three concentrations viz., 0.5, 0.25 and 0.175 g kg⁻¹ of cured turmeric rhizomes, whereas the normal diatomaceous earth was tested at one level viz., 5 g kg⁻¹ of cured turmeric rhizomes.

**Effect of nanocides on adult mortality of L. serricorne**

Laboratory bioassays were conducted to test the toxicity of nano particles using dry dust application. Different nano particles, viz, Nano silica @ 0.5g kg⁻¹, 0.25g kg⁻¹, 0.175g kg⁻¹ of cured turmeric rhizomes, Nano alumina @ 0.5g kg⁻¹, 0.25g kg⁻¹, 0.175g kg⁻¹ of cured turmeric rhizomes, Nano clay @ 0.5g kg⁻¹, 0.25g kg⁻¹, 0.175g kg⁻¹ of cured turmeric rhizomes and Diatomaceous earth @ 5g kg⁻¹ of cured turmeric rhizomes (check) along with control were used against beetle. The thoroughly dried cured turmeric rhizomes were treated with the test nano particles and five pairs of freshly emerged adults were released on to the nano particle treated cured turmeric rhizomes. All the treatments were replicated thrice. Adult mortality was assessed at 1, 2, 3, 4, 5, 6 and 7 days after exposure to the treated cured turmeric rhizomes. After studying the adult mortality, the cured turmeric rhizomes were placed back in the jars and kept undisturbed for the emergence of F1 progeny and the number of adults emerged from each treatment were recorded and analysed statistically by subjecting to analysis of variance using Completely Randomized Design (CRD). The mortality was observed daily and per cent adult mortality was calculated by using the following formula.

\[
\text{Number of adults dead} = \frac{\text{Total number of adults released}}{\text{Per cent adult mortality}} \times 100
\]

**Results and Discussion**

**Effect of nano particles on adult mortality of L. serricorne**

The results indicated that among the three nano treatments nano silica @ 0.5g kg⁻¹ and 0.25g kg⁻¹ was highly effective and caused cent per cent mortality at one day and two days after treatment (DAT), respectively and significantly on par with each other at one day after treatment, while nano silica applied @ 0.175g kg⁻¹ resulted in 86.67 and 96.67 per cent mortality at one day and two days after treatment, respectively and complete mortality was obtained at 3 days after treatment (Table 1). Nano alumina was less effective as compared to nano silica and caused cent per cent mortality at six days after treatment when applied @ 0.5g kg⁻¹ while 0.25g kg⁻¹ caused complete mortality at seven days after treatment. Lower concentration of 0.175g kg⁻¹ caused 93.33 per cent mortality at seven days after treatment. Nano clay used @ 0.5, 0.25 and 0.175 g kg⁻¹ recorded 23.33, 16.67 and 10.0 per cent adult mortality at one day after treatment and increased to 93.33, 86.67 and 73.33 per cent, respectively at seven days after treatment. Diatomaceous earth (DE) @ 5g kg⁻¹ recorded 6.67 per cent mortality at one day after treatment and it reached to 66.67 per cent mortality at seven days after treatment. Among all the treatments diatomaceous earth was least effective in controlling the pest.
Effect of nano particles on fecundity and adult emergence of *L. serricorne*

The fecundity and adult emergence studies indicated the superior performance of nano silica over other nano treatments (Table 2). The higher dosages of nano silica particles (0.5 g kg\(^{-1}\) and 0.25 g kg\(^{-1}\)) resulted in complete mortality of adults at one and two days after treatment (Table 2), hence the egg laying and adult emergence were not observed from the above treatments.

**Table 1:** Effect of nanocides on adult mortality of *L. serricorne*

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Dosage</th>
<th>Per cent adult mortality (Days after treatment (DAT))</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>Nanosilica @ 0.5 g kg(^{-1})</td>
<td>100.00 (90.00) 100.00 (90.00) 100.00 (90.00) 100.00 (90.00) 100.00 (90.00) 100.00 (90.00) 100.00 (90.00)</td>
</tr>
<tr>
<td>T2</td>
<td>Nanosilica @ 0.25 g kg(^{-1})</td>
<td>96.67 (83.84) 100.00 (90.00) 100.00 (90.00) 100.00 (90.00) 100.00 (90.00) 100.00 (90.00) 100.00 (90.00)</td>
</tr>
<tr>
<td>T3</td>
<td>Nanosilica @ 0.175 g kg(^{-1})</td>
<td>86.67 (68.82) 96.67 (83.84) 100.00 (90.00) 100.00 (90.00) 100.00 (90.00) 100.00 (90.00) 100.00 (90.00)</td>
</tr>
<tr>
<td>T4</td>
<td>Nanoalumina @ 0.5 g kg(^{-1})</td>
<td>66.67 (54.76) 73.33 (58.98) 80.00 (63.40) 93.33 (71.53) 100.00 (90.00) 100.00 (90.00) 100.00 (90.00)</td>
</tr>
<tr>
<td>T5</td>
<td>Nanoalumina @ 0.25 g kg(^{-1})</td>
<td>56.67 (48.82) 63.33 (52.75) 73.33 (63.40) 86.67 (77.69) 93.33 (77.69) 100.00 (90.00) 100.00 (90.00)</td>
</tr>
<tr>
<td>T6</td>
<td>Nanoalumina @ 0.175 g kg(^{-1})</td>
<td>33.33 (35.20) 43.33 (41.13) 56.67 (48.82) 73.33 (58.98) 83.33 (66.11) 93.33 (77.69) 100.00 (90.00)</td>
</tr>
<tr>
<td>T7</td>
<td>Nanoalumina @ 0.5 g kg(^{-1})</td>
<td>23.33 (18.42) 33.33 (23.76) 43.33 (28.76) 56.67 (35.20) 66.67 (41.13) 73.33 (48.82) 83.33 (52.75)</td>
</tr>
<tr>
<td>T8</td>
<td>Nanoalumina @ 0.25 g kg(^{-1})</td>
<td>16.67 (12.28) 26.67 (18.42) 36.67 (23.76) 43.33 (28.76) 50.00 (35.20) 56.67 (41.13) 63.33 (48.82)</td>
</tr>
<tr>
<td>T9</td>
<td>Nanoalumina @ 0.175 g kg(^{-1})</td>
<td>10.00 (9.00) 23.33 (18.42) 33.33 (23.76) 40.00 (28.76) 50.00 (35.20) 56.67 (41.13) 63.33 (48.82)</td>
</tr>
<tr>
<td>T10</td>
<td>Diatomaceous Earth @ 5 g kg(^{-1})</td>
<td>6.67 (12.28) 13.33 (21.13) 20.00 (26.55) 36.67 (37.21) 43.33 (41.13) 56.67 (48.82) 66.67 (54.76)</td>
</tr>
<tr>
<td>T11</td>
<td>Untreated check</td>
<td>0.00 (0.00) 0.00 (0.00) 0.00 (0.00) 0.00 (0.00) 0.00 (0.00) 0.00 (0.00) 0.00 (0.00)</td>
</tr>
</tbody>
</table>

CD (P=0.05) 9.51 7.53 3.63 3.88 7.25 6.67 8.34

SE(m) 3.22 2.55 1.23 1.31 2.45 2.26 2.82

CV (%) 13.06 9.09 4.00 3.94 6.91 5.91 6.82

Figures in parentheses are angular transformed values.

![Fig 1: Effect of nanocides on mean adult mortality of *L. serricorne*](image-url)
concentrations for all the three pests. The results are in agreement with further findings by Rouhani et al. (2013) \[12\] with nano silica applied @ 2.5 g kg\(^{-1}\) against C. chinensis., Deb Nath et al. (2011) \[4\] with nanosilica applied @ 2 g kg\(^{-1}\) against S. oryzae have achieved 100 per cent mortality and Stadler et al. (2012) \[16\] with nano alumina @ 125, 250, 500 and 1000 ppm against S. oryzae have obtained complete mortality at 15 days after treatment. Salem et al. (2015) \[13\] reported nano aluminum oxide against Tribolium castaneum have caused mortality and inhibited the number of progeny.

Conclusions
Among the three nanocides, nano silica applied at dosage of 0.5 g kg\(^{-1}\) and 0.25 g kg\(^{-1}\) caused immediate mortality and reduced oviposition and adult emergence of L. serricorne.

Acknowledgement
At the very outset, I submit the commodious and indefinite thanks to my family members, friends and teachers for successful accomplishment of three years in this college and to present this diminutive piece of work. I am grateful to Professor Jayashankar Telangana state agricultural University and Government of Telangana for the financial help in the form of stipend during my study period which can’t be forgettable.

References
1. Bhattacharyya A, Bhaumik A, Rani PU, Mandal S, Epi
t TD. Nano-particles - A recent approach to insect pest
2. Boraei DM, Nilly AH. Entomotoxic effect of aerosil nano
3. Deb Nath N, Mitra S, Sumistha D, Goswami A. Synthesis
11. Ravindran PN, Nirmal Babu K, Sivaraman K. Turmeric-
The genus Curcuma. CRC Press. 2012, 183-185
12. Rouhani M, Samih MA, Kalantari S. Insecticidal effect of

### Table 2: Effect of nanocides on fecundity and adult emergence of L. serricorne

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Dosage</th>
<th>Fecundity (50 g of cured turmeric rhizomes)</th>
<th>Number of adults emerged</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>Nanosilica @ 0.5g kg(^{-1})</td>
<td>0.00 (1.00)</td>
<td>0.00 (1.00)</td>
</tr>
<tr>
<td>T2</td>
<td>Nanosilica @ 0.25g kg(^{-1})</td>
<td>0.00 (1.00)</td>
<td>0.00 (1.00)</td>
</tr>
<tr>
<td>T3</td>
<td>Nanosilica @ 0.175g kg(^{-1})</td>
<td>2.33 (1.82)</td>
<td>0.00 (1.00)</td>
</tr>
<tr>
<td>T4</td>
<td>Nanoalumina @ 0.5 g kg(^{-1})</td>
<td>8.67 (3.10)</td>
<td>2.67 (1.91)</td>
</tr>
<tr>
<td>T5</td>
<td>Nanoalumina @ 0.25g kg(^{-1})</td>
<td>12.33 (3.65)</td>
<td>5.33 (2.51)</td>
</tr>
<tr>
<td>T6</td>
<td>Nanoalumina @ 0.175g kg(^{-1})</td>
<td>17.67 (4.32)</td>
<td>7.33 (2.87)</td>
</tr>
<tr>
<td>T7</td>
<td>Nanoclay @ 0.5g kg(^{-1})</td>
<td>15.67 (4.08)</td>
<td>8.00 (2.99)</td>
</tr>
<tr>
<td>T8</td>
<td>Nanoclay @ 0.25g kg(^{-1})</td>
<td>19.33 (4.50)</td>
<td>9.33 (3.220)</td>
</tr>
<tr>
<td>T9</td>
<td>Nanoclay @ 0.175g kg(^{-1})</td>
<td>29.33 (5.50)</td>
<td>17.00 (4.24)</td>
</tr>
<tr>
<td>T10</td>
<td>Diatomaceous Earth @ 5g kg(^{-1})</td>
<td>38.67 (6.29)</td>
<td>24.67 (5.06)</td>
</tr>
<tr>
<td>T11</td>
<td>Untreated check</td>
<td>76.33 (8.79)</td>
<td>73.00 (8.60)</td>
</tr>
</tbody>
</table>

*Figures in parentheses are square root transformed values

The lower dosages of nano silica (0.175g kg\(^{-1}\)) which caused cent per cent mortality of adults at three days after treatment resulted in very low oviposition (2.33 eggs) by the beetle. The few eggs laid by the insect also did not develop in to adults at time of exposure. Similarly, Boraei and Nilly (2015) \[2\] also reported that the toxicity of silica nano particles at different concentrations against three main stored grain insects viz., Sitophilus oryzae, at 2.5 g kg\(^{-1}\), R. dominica at 1.5 g kg\(^{-1}\) and Callosobruchus maculatus at 1g kg\(^{-1}\) had shown 100 per cent mortality of insects also further indicated that the complete reduction in F\(_1\) progeny obtained at the same concentrations for all the three pests. The results are in agreement with further findings by Rouhani et al. (2013) \[12\] with nano silica applied @ 2.5 g kg\(^{-1}\) against C. chinensis., Deb Nath et al. (2011) \[4\] with nanosilica applied @ 2 g kg\(^{-1}\) against S. oryzae have achieved 100 per cent mortality and Stadler et al. (2012) \[16\] with nano alumina @ 125, 250, 500 and 1000 ppm against S. oryzae have obtained complete mortality at 15 days after treatment. Salem et al. (2015) \[13\] reported nano aluminum oxide against Tribolium castaneum have caused mortality and inhibited the number of progeny.


15. Stadler T, Buteler M, Weaver DK, Sofie S. Comparative toxicity of nano structured alumina and a commercial inert dust for *Sitophilus oryzae* (L.) and *Rhyzopertha dominica* (F.) at varying ambient humidity levels. Journal of Stored Product Research. 2012; 48:81-90.
