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Efficacy of Chlorfenapyr Against Adult of Red Flour Beetle, *Tribolium Castaneum* (Herbst; Coleoptera) Exposed on Different Nonporous And Porous Surfaces.

Geetanjali A. Thorat[1], Dr. S.G.Salokhe[2]
[1]*Department of Zoology, Ramakrishna More College, Pune University, India.*
[2]*Department of Zoology, Ramakrishna More College, Pune University, India.*
Corresponding Author: Geetanjali A. Thorat
**Corresponding Author: Dr. S.G. Salokhe*

Abstract: *Red flour beetle Tribolium castaneum (Herbst) is major pest of stored products especially cereal flour, which depreciating the quality and quantity of food economically. The method of controlling these pests is use of chemical pesticides. The pest control operations, the structural facilities or the different sites containing store, grocery shops, go-downs, grains stored in government warehouses are performed on variety of surfaces. The efficacy of different insecticides would vary on different surface substrates. The insecticide, Chlorfenapyr, an insecticidal pyrole (INTREPID^{TM}) BASF other name Chlorfenapyr-4-bromo-2(4chlorophyenyl)-1-(ethoxymethyl)-5-(trifluromethyl)-pyrrole3-carbonitrile, was applied to nonporous (glass, tile, metal, and wood laminate) and porous (concrete sheet and cow dung sheet) arenas at various concentrations at 28x28cm^2. Adults of Tribolium castaneum (Herbst), the red flour beetle were exposed for 24 hrs at different concentrations on each different surface. The same arenas which were treated for adults with LC_{50} concentration of that particular nonporous and porous surface which were also observed for its efficacy in days. The LC_{50} values of adults on glass, tile, metal, and wood laminate were 0.007273%, 0.007646%, 0.0137%, 0.029093% respectively and on concrete and cow dung were 0.076455%, 0.0664% respectively. The toxicity result revealed that the insecticide had the most efficacies on glass surface, followed by tile, metal, wood laminate, cow dung sheet, concrete surfaces respectively. The non- porous surfaces were effective highly for first three to four days and slowly decline upto 10th day. In the porous surface cow dung were effective up to 7 days and concrete surface up to 5 days only. Therefore in general, the non-porous surfaces were the best effective at low concentrations as compared with porous surfaces.*

Keywords: *Chlorfenapyr, insecticide, LC_{50} , treated surfaces Tribolium castaneum*

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I. Introduction

Tribolium castaneum is a world-wide pest commonly found in raw stored grains milling facilities and food ware houses, retail stores and Urban homes[1].They are often more difficult to kill than other stored product beetles, through the order of toxicity will often vary depending on the particular insecticide [2]. In many indoor facilities the presence of food material through spillage and the manufacturing and milling processes offer harbourage sites where insects can escape exposure to insecticides [3] Ecological implications for post-harvest IPM of grain and grain based product are depend on Ecologically Based Integrated Pest Management [4] Red Flour Beetle damages stored products by feeding and severely reducing the quality of crops due to product excrement and larval and adult faces. The pest makes a very serious damage to the flour and crush cereal particularly at any larval stages as well as adult stage. This pest causes damage to the seeds with high humidity (usually above 12%), and therefore it makes the changing of colour of the flour to grey and creates a bad smell to the nutrient materials. The pest continuation on such nutrient material caused to mould growth on grain and flour.

Chlorfenapyr is an insecticidal pyrrole that inhibits Adenosine Tri Phoshate (ATP) production in the cellular structure of insects [5]. It is a novel insecticide used for the control of veterinary and agricultural pests [6]. As a pro-insecticide activated by oxygenase to a more toxic metabolite AC-303, 268, a powerful mitochondrial uncoupler it has unique mechanism of action distinctly from commonly used neurotoxic insecticides [7]. Chlorfenapyr is used to control two- spotted spider mites *Tetranychus urticae* [8] and subterranean termites *Reticulitermes besperus* [9]. It has also been used in the cattle industry in the impregnated ear tags to control *Haematoba* irritans [10]. Chlorfenapyr is an effective larvicide against the dengue vector *Ades aegypti,* and moderately toxic to *Ades aegypti* adults [11]. Contact insecticides remain the important option

for controlling stored product insects. As a part of IPM programme the insecticides can be applied to floors and walls of food storage sites. The efficacy of insecticide will often vary depending on the surface substrate, as documented in studies with urban insects [12 &13]

By using fumigants and residual chemical insecticides the arthropod pests on stored products has controlled and required adequate and continuous attention to storage warehouses, during transportation and silo cells [14]. Research has shown that the pest control operations, in structural facilities or sites containing processed food products, consume and on store are performed on variety of surface substrates.

The surfaces chosen for this study were concrete, metal- sheet, glass that could be encountered in structural insect pest management. Apart from this the other surfaces tile, wood laminate, cow-dung sheets (from Indian context) were used which are generally present in godown, grain storage areas of retailers and restaurants. The surfaces were observed for their treatment effectivety in duration.

Aim and objectives of studies

- To study the efficacy of Chlorfenapyr against adults of *Tribolium castaneum* exposed to various surfaces.
- To calculate LC_{50} values of Chlorfenapyr for adults of *Tribolium castaneum*, exposed to various surfaces.
- To identify the surface that given most efficacy to control adults of *Tribolium castaneum*, by Chlorfenapyr treatment in less concentration.
- To investigate the surfaces that given most efficacy to control adult *Tribolium castaneum*, by Chlorfenapyr treatment for longer duration.

II. Material And Methods

1. Maintenance of culture of *Tribolium castaneum*

Tribolium castaneum culture was maintained on diet containing wheat flour and 5% Brewer's yeast, at 29 ± 1^0 C and 60 % relative humidity. Eggs were collected by sieving (sieve number 40) diet infested with adults. Newly emerged adult were obtained by collecting pupae and monitoring them for adult emergence.

2. Insecticide

The insecticide tested, Chlorfenapyr 10% SC, an insecticidal pyrole (INTREPID^{TM}) BASF other name Chlorfenapyr-4-bromo-2(4chlorophyenyl)-1-(ethoxymethyl)-5-(trifluromethyl)-pyrrole3-carbonitrile

3. Bioassys

The bioassay experiments of the insecticide were done in six different surfaces of which four are nonporous and two are porous. The different nonporous surfaces are glass, tile, metal, wood laminate sheet. The glass surfaces used were glass Petri-dishes of area 28.28cm^2. The circles were marked on sheets of tile, metal, and wood laminate surfaces with glass Petri-dishes of same size.

The porous sheet, plain concrete and plain cow-dung sheet were prepared by slurry of equal amount of material, cement as well as cow-dung and water by spreading on plain plywood sheet at supportive base, equal amount slurry formed with equal amount of water of concrete and cow-dung sheets. Both the sheets were allowed to dry for two weeks. Thickness of non-porous sheets surfaces was 1.25cm.

The area of each surface was 28.28cm^2. Surfaces were treated by 0.5ml of Chlorfenapyr with different concentrations. The ranges of concentrations were determinate for the insecticide by primarily dose-response experiments. These different doses were applied using artist's paintbrush of number 4 (thick brush to spread the chemical at equal layer and equal amount on the prefixed arenas). Ten adults of *Tribolium castaneum* were introduced on each dried surface. It was covered with the inverted same size petri- plate. The observations on mortality were made after 24 hours of the treatment. Procedure was carried out in triplicate.

The LC_{50} was calculated using probit analysis for adult *Tribolium castaneum* [15]. The analysis was done by regression.

Residual efficacy of Chlorfenapyr was evaluated against adult *Tribolium castaneum.* LC_{50} (for adult *Tribolium castaneum*) concentration derived from the above experiment, was used for each surface treatment. On the same treated surfaces, 10 uniform aged adults were kept every day. This procedure was continued for 10 days. Thus residual effect of the LC_{50} of Chlorfenapyr was calculated for various surfaces residual effect.

III. Results

The LC_{50} values of Chlorfenapyr for adult *Tribolium castaneum* on the glass, tile, metal, wood laminate, cow dung, concrete surfaces, calculated were showed in Table1. It was observed that on non-porous surfaces, tile and glass surfaces LC_{50} values were minimum while on porous surfaces such as concrete and cow dung surfaces it was maximum. The result showed that Chlorfenapyr had highest efficacy on glass surface followed by tile, metal, wood laminate, cow dung, concrete surfaces, respectively.

The LC_{50} values for adults exposed to the variable surfaces treated by Chlorfenapyr, , according to surface porosity. In addition, the results showed that Chlorfenapyr had the most efficacies against adult *Tribolium castaneum*, when applied on glass and tile surfaces compared to the others (fig 1 to 6).

The efficacy of LC_{50} Chlorfenapyr on different surfaces against adult *Tribolium castaneum* showed maximum duration effect upto 10days on glass surface with lowest LC_{50} concentration (0.007273%) and minimum duration effect upto 5 days on treated concrete surface with highest LC_{50} concentration (0.076455%). The tile surface which was treated on day one was effective upto 8th day of the treatment and showed 3% mortality on 8th day after treatment. There was no significant difference in mortality on treated metal surface or tile surface. The treated wood laminate surface was effective for 7days and the mortality was 7% on the7th day after treatment to the surface. Among the nonporous surfaces the treated cow dung surface was more effective. It showed mortality effect upto 7th day after treatment. The treated concrete surface was lowest effective that was upto 5 days only (Table 2, fig 7).

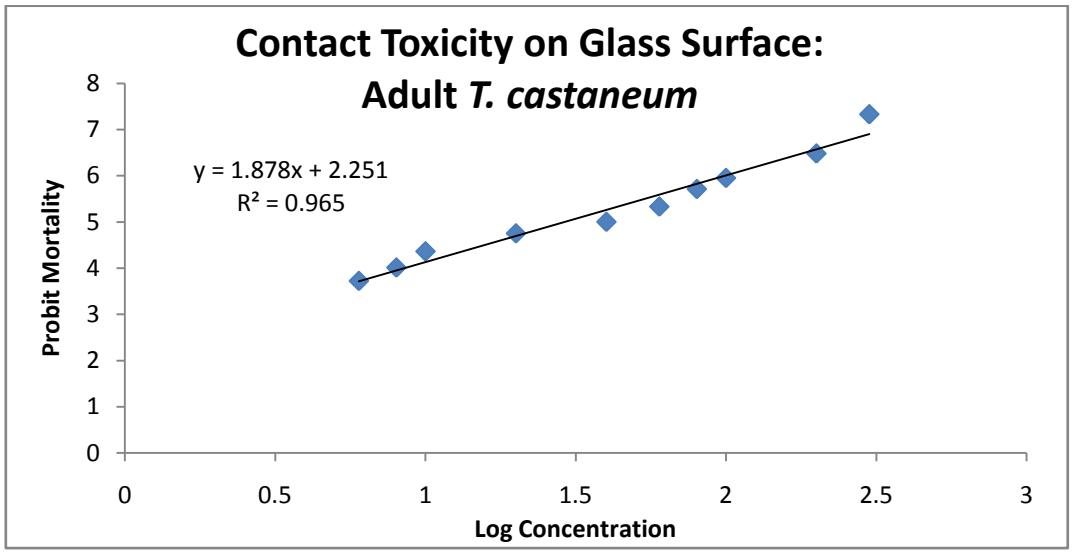

Fig. 1 Glass surface, LC_{50} = 0.007273%

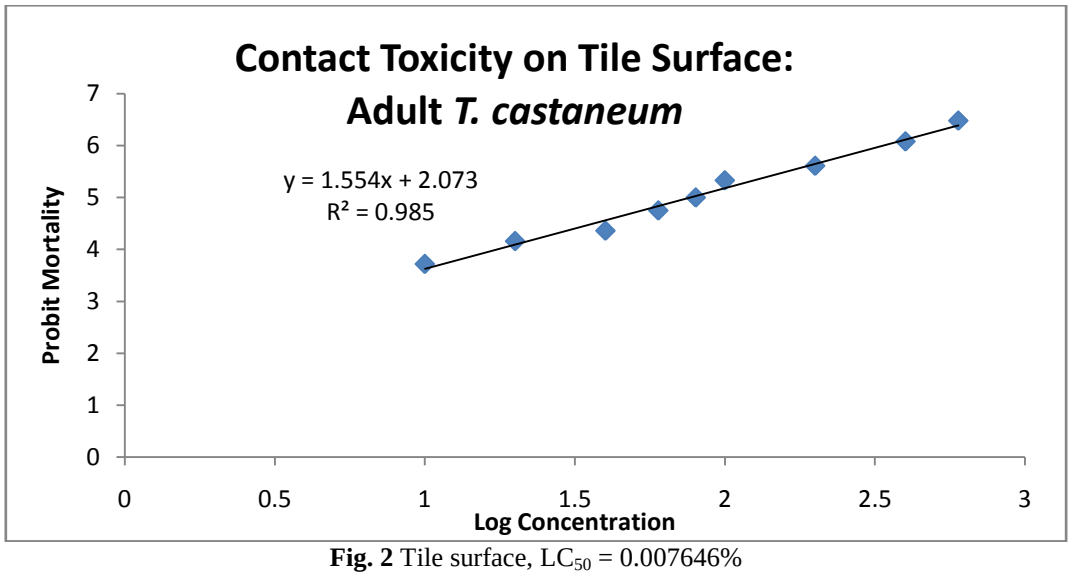

Fig. 2 Tile surface, LC_{50} = 0.007646%

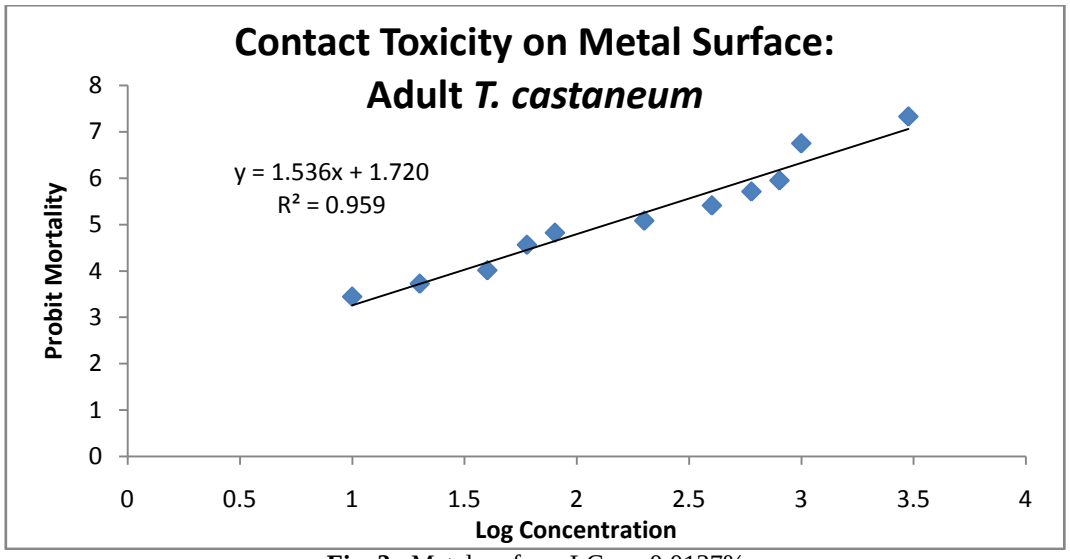

Fig. 3 Metal surface, LC_{50} = 0.0137%

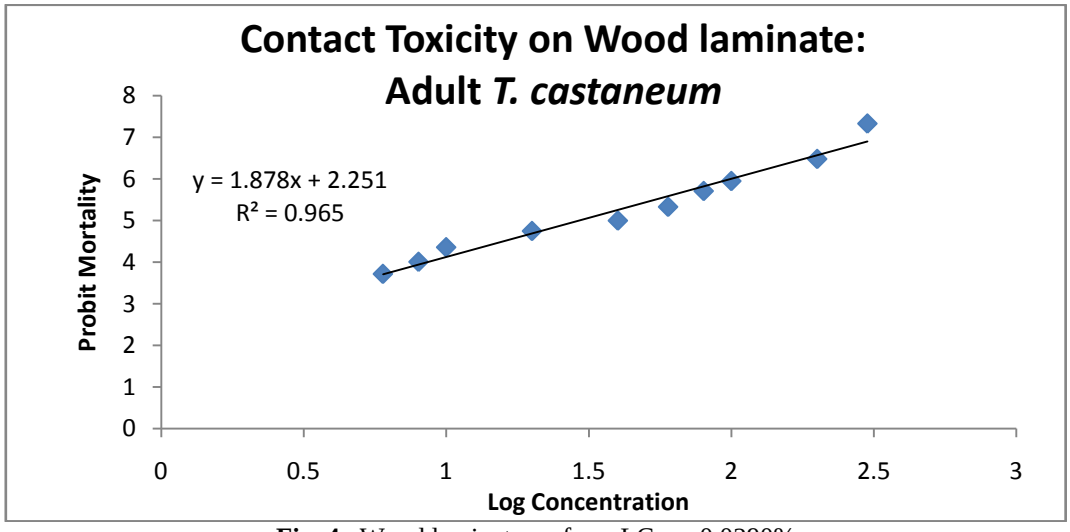

Fig. 4 Wood laminate surface, LC_{50} = 0.0290%

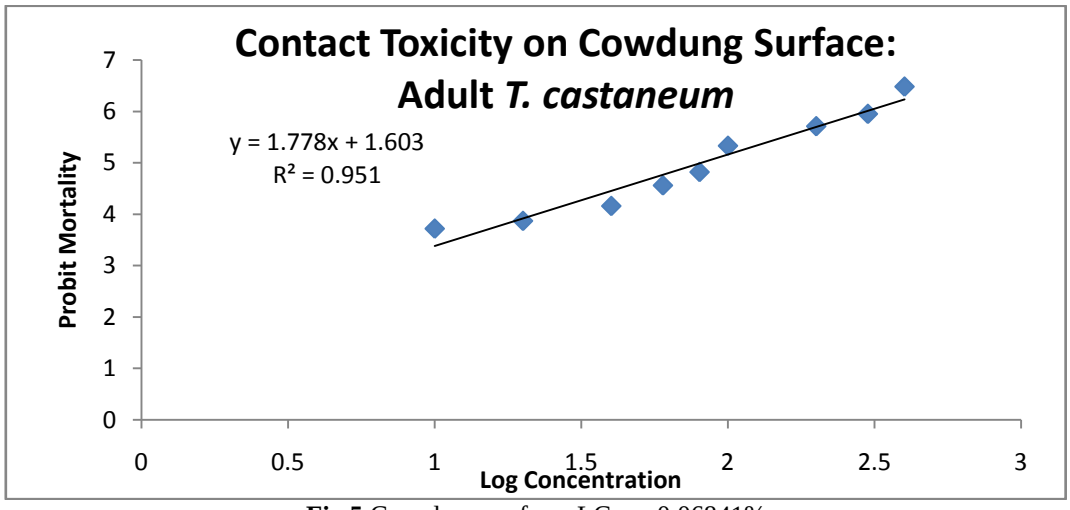

Fig 5 Cow dung surface, LC_{50} = 0.06841%

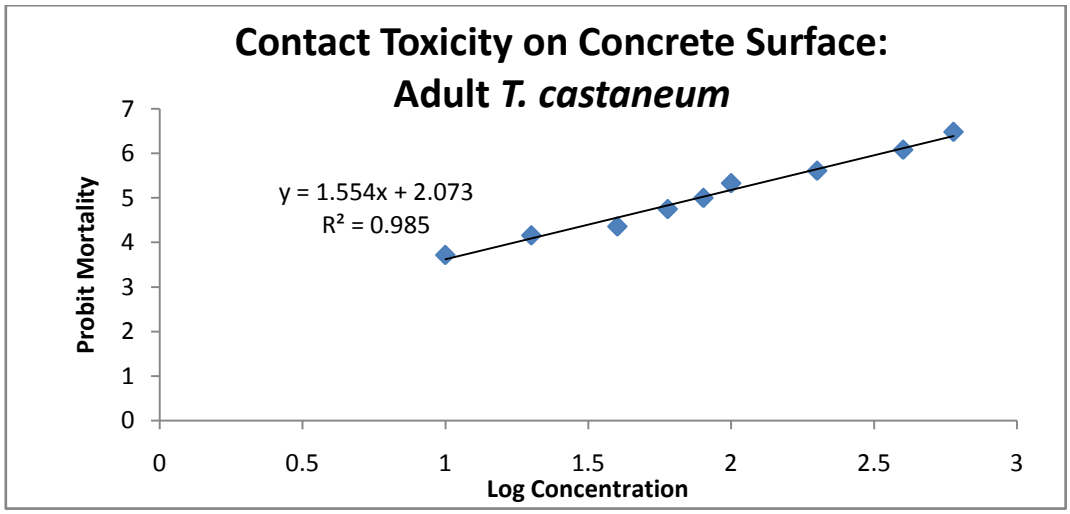

Fig6 Concrete surface, LC_{50} = 0.07645%

Table 1- LC_{50} of Chlorfenapyr for *T. castaneum* adults exposed to different surfaces.

Surface type	**LC_{50}**
Glass	0.007273%
Tile	0.007646%
Metal	0.0137%
Wood laminate	0.029093%
Cow dung	0.06455%
Concrete	0.076455%

Table 2 - Residual effect of Chlorfenapyr LC50

	Mortality at days intervals									
Surface type	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10
Glass	50%	50%	50%	50%	40%	37%	23%	17%	10%	7%
Tile	50%	50%	50%	47%	40%	23%	13%	7%	3%	0%
Metal	50%	50%	50%	47%	37%	23%	10%	3%	0%	0%
Wood laminate	50%	50%	47%	37%	33%	17%	7%	3%	0%	0%
Cow dung	50%	50%	43%	37%	30%	17%	7%	0%	0%	0%
Concrete	50%	40%	33%	17%	7%	0%	0%	0%	0%	0%

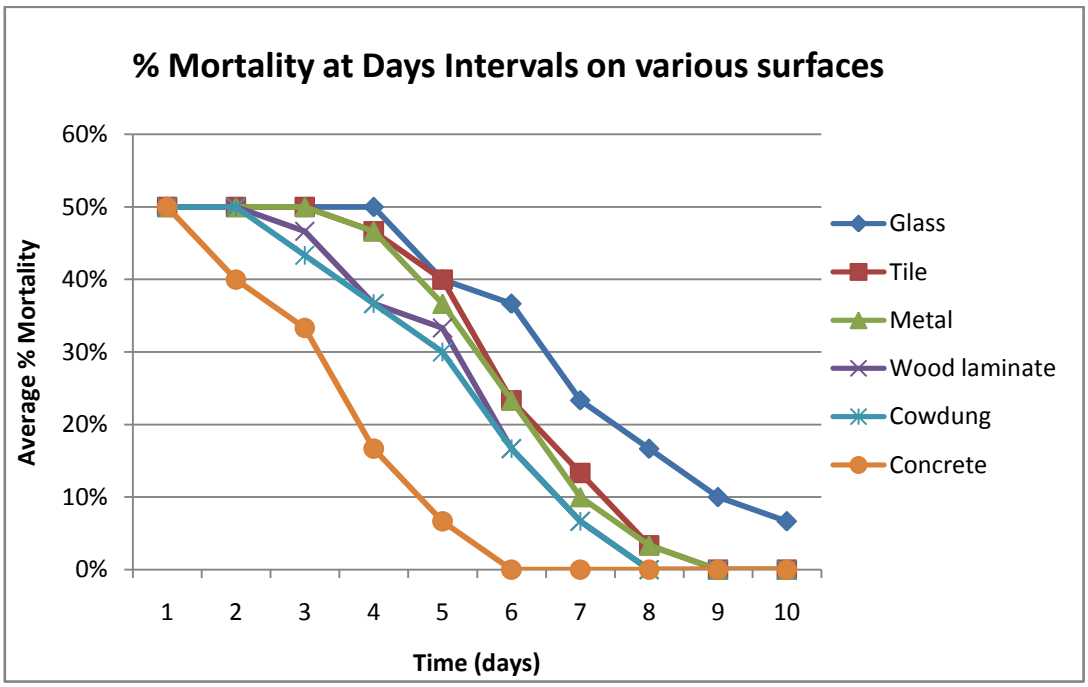

Fig. 7 Percentage Mortality of adult *Tribolium castaneum* at Days Intervals on Different Surfaces

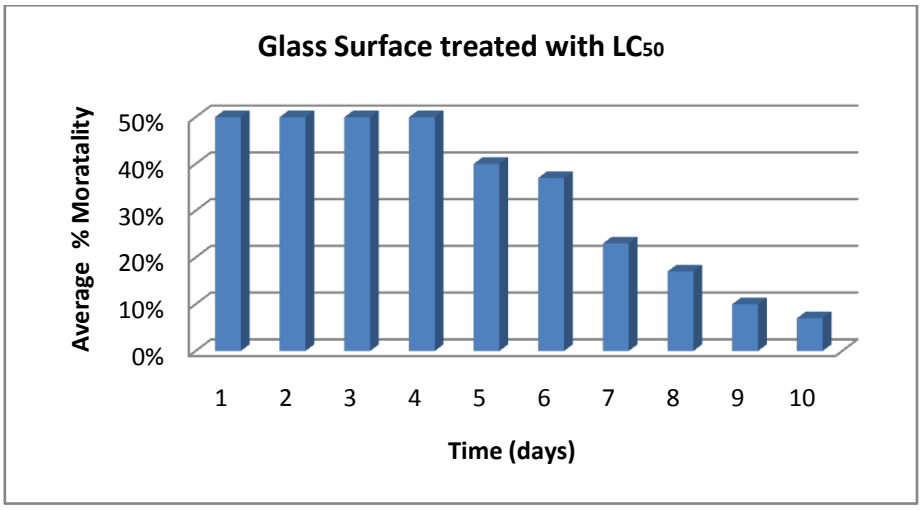

Fig. 8 LC_{50} Treatment on glass surface

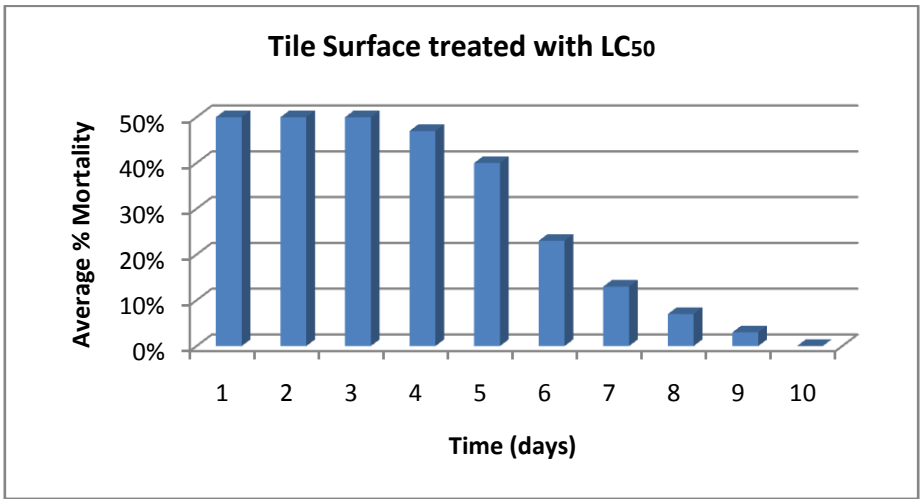

Fig. 9 LC_{50} Treatment on tile surface

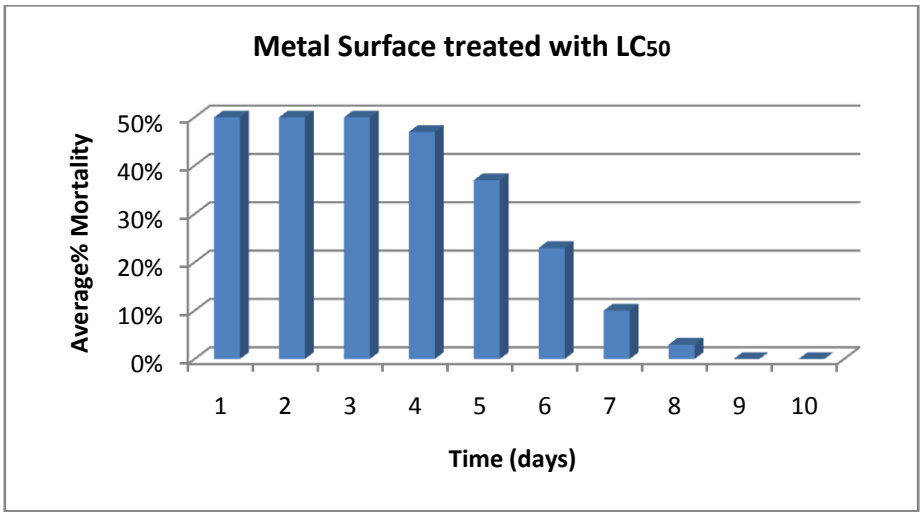

Fig. 10 LC_{50} Treatment on metal surface

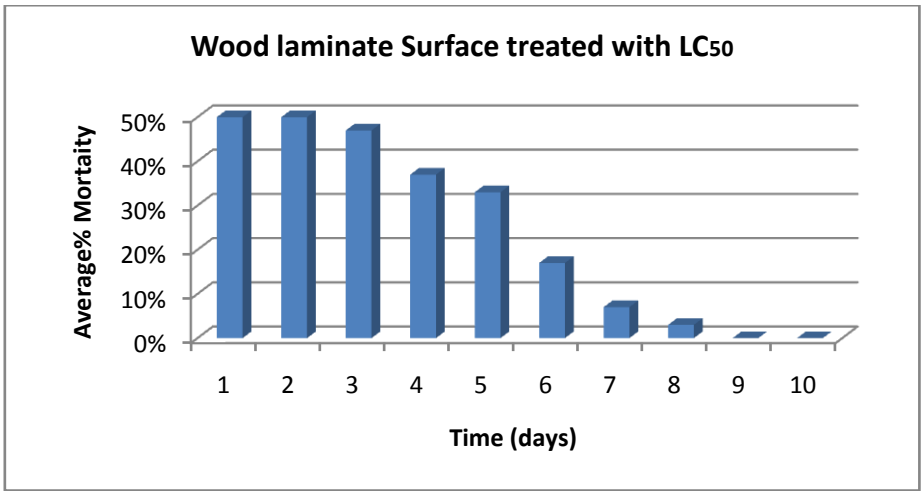

Fig. 11 LC_{50} Treatment on wood laminate surface

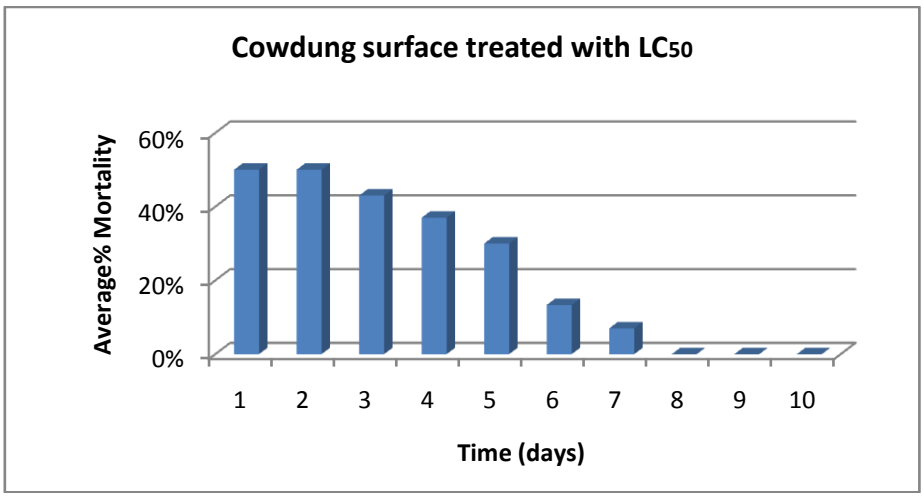

Fig. 12 LC_{50} Treatment on cow dung surface

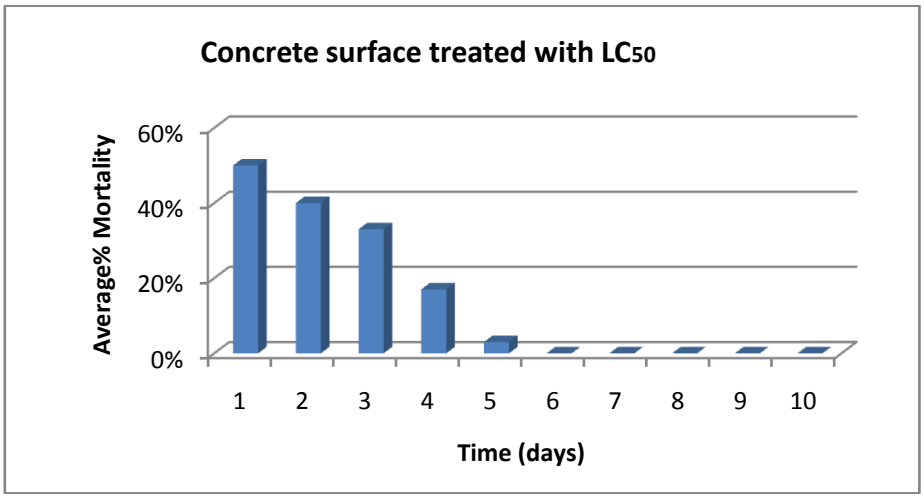

Fig. 13 LC_{50} Treatment on concrete surface

IV. Discussion

LC_{50} of Chlorfenapyr was found to be effective diagnostic concentrations for insecticide susceptibility tests. In laboratory conditions, persistence of different doses of Chlorfenapyr on six different substrates revealed that the toxicity of Chlorfenapyr was different on the different surfaces. Survival of red flour beetle was lower on glass surfaces than tile, metal, wood - laminate, cow dung, concrete surfaces, respectively. Similar results were reported for Chlorfenapyr was the most effective against *Tribolium castaneum* and *Tribolium confusum*,

but efficacy will vary depending on the surface substrate [16]. The effect of spinosad against eight species of stored- product beetle exposed to four surfaces, and revealed that *Tribolium* species were highly susceptible to spinosad on concrete (98%-100% mortality) , however, on un-waxed floor tile, steel, and waxed floor tile resulted in only 72%-92% mortality [17].

In the present study it was observed that most effective surface was glass as it showed maximum mortality at low concentration and longer period of persistence for 10 days after treatment of LC_{50} (0.007273%). Similarly tile surface was effective for 9 days at LC_{50} 0.007646%. The surface efficacy on metal and wood laminate sheet was same up to 8days, with LC_{50} values (0.0137% and 0.029093% respectively). Between the porous surfaces, cow dung surface was effective for 7days at LC_{50} (0.06455%) and concrete surface was least effective that was for 5 days only with LC_{50} value (0.076455%).Similar results were found by Arthur in the residual efficacy of Cyfluthrin emulsifiable concentrate and wettable powder formulations on porous concrete and on concrete sealed with commercial products prior to insecticide application [18]. Also effectiveness of deltamethrin dust on plywood, concrete and tile surfaces against three stored product beetle is best on slick surfaces such as steel or ceramic tile in comparison to more porous surfaces [19].

In conclusion the result showed that efficacy of tested insecticide was much higher on smooth and flat surfaces, such as glass, tile, metal, wood laminate. Efficacy duration of porous surfaces less on firstly cow dung and then on concrete. Similar results were reported against *Tribolium castaneum* for insecticides Deltamethrin, Chlorpyrifos, Abamectin etc [16]. Also the efficacy, was found to be best on non-porous surfaces, such as steel or ceramic tile compared with more porous surface of concrete[17 and 18].

Hence Chlorfenapyr can be used to control the red flour beetle in grain storage sites especially with nonporous surfaces which gives longer duration effect as compare to porous surface storage sites. The results revealed that efficacy of insecticide Chlorfenapyr was also related to surface texture.

Reference

[1]. D. Rees, Insect of stored Products, SIRO Publishing, Collingwood, Vic, Australia 2004, p.181
[2]. Arthur FH (2009) Efficacy of Chlorfenapyr against adult *Tribolium castaneum* exposed on concrete: effects of exposure interval, concentration, and the presence of a food source after exposure. Insect Sci 16:157-163
[3]. Toews MD, Campbell JF, Arthur FH, West M (2005) Monitoring *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae) in pilot scale warehouses treated with residual applications of (S) hydroprene and cyfluthrin. J Econ Entomol 98:1391-1398.
[4]. O. Koul and GW Cuperus Integrated Pest Management: Potential, Constrains and Challenges , pp 406-431, 2010,CABI publishing, Walling ford UK.
[5]. Mc Lead et al, (2002), Toxicity, Persistence and Efficacy of spinosad Chlorfenapyr and Thiamethaxam on Egg plant when applied against egg plant Flea Beetle.
[6]. Lovell et. al.1990, A gene mapping to the sex-determining region of the mouse Y chromosome is a member of a novel family of embyonically expressed genes, Nature 346, 245-250.
[7]. Black B.C., Hollingsworth RM, Ahammadsahib KL, Kukel CD, Donovan S: Insecticidalaction and mitochondrial uncoupling activity of AC-303,630 and related halogenated pyrroles.*Pest Biochem Physio1*994,50:115-`128
[8]. Herron G.A. and Rophail 2003.First detectation of Chlorfenapyr (Secure(R)) resistance in two – spotted spider mite (Acari : Tetranychidae) from nectarines in
[9]. Rust and Saran et al. 2006 ,Toxicity, repellency and transfer of Chlorfenapyr against western Termites and Sustainable subterranean termites ,Isoptera : hinotermitae , Research gate publication.
[10]. Guglielmone et. al. Science Direct 2000, Chlorfenapyr ear tags to control *Haematoba irritans* (L) Diptera : Muscidae) on cattle , Volume 93, issue 1,Pages 77-82.
[11]. Paul et. al. 2006, Evaluation of novel insecticides for control of dengue vector *Ades aegypti* adults, J Med Entomol, NCBI,43(1):55-60..
[12]. Chadwick1985, Branesss and Bennet 1990 and with stored product insects
[13]. Williams et.al.1983,Samson and Hall1989,Arthur1994 ,1997,Collins et al 2000.
[14]. C.L.Storey, D.B.Sauer, D.Walke, Present use of pest management practices in wheat, corn, and oats stored on The farm, Journal of Economic Entomology 77 1984,784-788).
[15]. Finney 1971 probit analysis
[16]. Arthur FH (2008) Efficacy of Chlorfenapyr against adult *Tribolium castaneum* and *Tribolium confusum* (Coleoptera: Tenebrionidae) exposed on concrete, vinyl tile, and plywood surfaces. J. Stored Prod Res 44:145-151
[17]. Towes et al (2003) studied effect of spinosad against eight species of stored- product beetle exposed to four surfaces, and reported that *Tribolium* species were highly susceptible to spinosad on concrete (98%-100% mortality).
[18]. F. H. Arthur, Residual efficacy of cyfluthrin emulsifiable concentrate and wettable powder formulations on porous concrete and on concrete sealed with commercial products prior to insecticide application, Journal of Stored Products research 30 (1994) 79-86. 14.J.L.Robertson, H.K.Preisler, Pesticide Bioasssys with Arthropods, CRC Press Inc.,1992,p127.
[19]. F. H. Aurthur, Diff. effectiveness of deltamethrin dust on plywood, concrete and tile surfaces against three stored product beetle, journal of Stored product Research33(1997)107-173.
[20]. Wiltz BA, Suiter DR, Gardner W A(2009) Activitiy of bifenthrin , Chlorfenapyr, fipronil, and thiamethoxam against Argentine ants (Hymenoptera: Formicidae). J Econ Entomol 102:2279-2288
[21]. Campbell JF, Toews MD, Arthur FH, Arbogast RT (2010b) Long term monitoring of *Tribolium castaneum* in two flour mills: seasonal patterns and impact of fumigation. J Econ Entomol 103:991- 1001
[22]. M.D. Toews, B. Subramanyam, J.M. Rowan, Knockdown and mortality of adults of eight species of stored- product beetles exposed to four surfaces treated with spinosad, Journal of economic Entomology 96 (2003), 1967-1973.
[23]. Arthur F.H., Dowdy, A. K.,(2003) Efficacy of a volatile formulation of hydroprene (Pointsource) to control *Tribolium castaneum* and *Tribolium confusum* (Coleoptera: Tenebrionidae) to new formulations of hydroprene. J. Stored Prod Res 39:193-204.

[24]. Arbogast,R.T., Kendra, P.E., Mankin,R.W., McDonald, R.C.,2002.Insect Infestation of a botanicals warehouse in north-central Florida. J. Stored Prod Res 38:349-363.
[25]. Kamaraju Raghvendra, Tapan K Barik,Chlorfenapyr: a new insecticide with noval mode of action can control pyrithroid resistant malaria vectors. Malaria Journal 2011,10:16
[26]. Oxborough RM,Kitau J. Matowo J, Mndeme R, Feston E, MoshaFW, Rowland MW:Evaluation of indoor residual sprying with the pyrole insecticide chlorfenapyr against pyrethroid susceptible Anopheles arabiensis and resistant *Culex quinquefasciatus* mosquitoes, *Trans R Soc Trop Med Hyg* 2010,104(10)639-45.
[27]. Stumpf N.Nauen R:Cross- resistance, inheritance, and biochemistry of mitochondrial electron transport inhibitor- acaricide resistance in Tetranychus urticae(Acari: Tetranychidae) . *J Econ.Entomol* 2001,94:1577-1583.
[28]. Rand GM:Fate and effects of the insecticide- miticide Chlorfenapyr in outdoor aquatic microcosms. *Ecotoxicol Environ Saf* 2004,58:50-60.
[29]. Campbell,J.F.,F.H. Arthur, and M.A.Mullen,2004.Insect management in food processing fascilities, pp.240-295.In S. Tayler(ed.),Advances in food and nutrition research, vol 48.Elsevier,New York.
[30]. Arthur FH,Efficacy of methoprene for multi-year protection of stored wheat, brown rice,rough rice an corn. *J Stored prod.Res*.2016,68,85-95.
[31]. Arthur, F.H. Residual efficacy of pyrethrins+methprene for control of *Tribolium castaneum and Triblolium confusum* in a commercial flour mill. *J Stored prod.Res*.2015,64,42-44.
[32]. Jenson,E.A; Arthur, F.H.;Nechols,J.R.Efficacy of an esfenvaleratebplus methoprene aerosol for the *control* of eggs and fifth instars of the Indianmeal moth (Lepidoptera:pyralidae).*Insect Sci*.2010,17,21-28.
[33]. Arthur A.H.(2008) Efficacy of Chlorfenapyr against *Tribolium castaneum* (coleoptera: Tenebrionidae) adults exposed on concrete, vinyl tile and plywood surfaces, journal of Stored Products Research 44(2008)145-151).

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