Available online at http://www.ijcrls.com

International Journal of Current Research in Life Sciences
Vol. 07, No. 08, pp.2604-2608, August, 2018

ISSN: 2319-9490

RESEARCH ARTICLE

PHOSPHINE FUMIGATION FOR PROTECTION OF WOOD FROM *SINOXYLON ANALE* (COLEOPTERA: BOSTRYCHIDAE) ATTACK IN INDIAN CONDITIONS

[1]Remadevi, O.K. and [1,*]Deepthi, T.R.

[1]Environmental Management and Policy Research Institute (EMPRI), "Hasiru Bhavana", Doresanipalya Forest Campus, Bangalore 560 078, India
[1]Department of Zoology, NSS Hindu College, Changanacherry, Kerala, India

Received 04th June, 2018; Accepted 17th July, 2018; Published 30th August, 2018

ABSTRACT

Different concentrations of phosphine were tested against adults of Sinoxylon anale in de-siccator tests. The mortality was 75%, 85% and 100% at 100, 150, and 200ppm levels of the gas respectively. LC50 is calculated and is 61.73 ppm. In the field trials using infested stacked logs of Subabul, observations were taken about the response of baited insects against dif-ferent doses of phosphine. After 72 hours, samples of wood logs were removed from differ-ent levels of the stack, autopsied. Observations were taken on the effectiveness of phos-phine against different developmental stages of the insect and were found dead indicating a good penetration of phosphine in to the logs. The study indicated that phosphine fumigation can be adopted to cure the infestation of S. anale in wooden logs and products.

Key words: Fumigation, Phosphine, Methyl bromide, Wood boring insects, Sinoxylon anale.

Citation: Remadevi, O.K. and Deepthi, T.R. "Phosphine fumigation for protection of wood from Sinoxylon anale (Co-leoptera : Bostrychidae)attack in Indian conditions" *International Journal of Current Research in Life Sciences*, 7, (08), 2604-2608.

INTRODUCTION

World over, insect pest elimination in stored products including food commodities are carried out by fumigation. Fumigation is a widely used method all over the world on small as well as large storage scale. Fumigants are low molecular weight chemicals, highly toxic and volatile, that are used during storage to kill all insect stages residing in the produce. Phosphine is used for fumigating a wide bank of insects and pests. It has a low degree by food stuffs and penetrates well in to the stored products. Phosphine is the most widely used fumigant and is increasingly used as a treatment to replace Methyl bromide. It is used as an insecticide for the fumigation of grains, animal feed, and stored tobacco and as a rodenticide Phosphine used for fumigation purposes is generally produced by the reaction of atmospheric moisture with slow release formulations containing Aluminium or Magnesium phosphide. In Indian conditions, powderpost beetles damage wood in storages and also after converting into products. Powder post beetles attack and destroy hardwood which has at least moderate starch content. Their attack is confined to the sapwood of pored timbers, whereas conifers are generally not susceptible. The consequences of infestation are summarized by the term "powder post".

Corresponding author: **Deepthi, T.R.,**
Department of Zoology, NSS Hindu College, Changanacherry, Kerala, India.

Wood when heavily attacked is reduced to fine powder by the adults and immature beetles (Bostrychidae) or the larvae (Lyctidae). They leave the outer layer of the wood intact whilst destroying all within. Both families are globally known as timber pests. The family Bostrychidae includes a number of important insect species, which are harmful to timber and timber products. Hence, the beetles are of considerable economic importance to forestry and the wood-using industries. The Bostrychidae represent a highly destructive group of wood-boring and stored product beetles. *Sinoxylon anale* is the most devastating wood pest. *S. anale* is a common bostrychid which occur throughout India within forests, timber depots and saw mill. The adults bore tunnels into the sapwood and eggs are laid inside. On hatching larvae excavate sapwood by making more or less straight, often intersecting lines, which are circular in section and tightly packed with fine wood dust. The larvae are white, curved with short legs and measuring up to 6mm. Larvae pupate in a cell at the extreme end of the larval tunnel and beetles bore out directly to the surface.

The beetles are on wing from March – October. Scientific studies on the applicability of Phosphine for fumigating wood to control wood boring insects are few. So far, studies on the efficacy of Phosphine fumigation against wood borers have been conducted only abroad. Use of phosphine for wood fumigation to control wood boring insects is not being practiced in India and this is a pioneer attempt in these lines in India.

MATERIALS AND METHODS

Laboratory experiment was carried out in the Entomology department of Institute of Wood Science and Technology(IWST), B'lore.

Fumigation – Laboratory trial: Phosphine gas was generated using commercially available Aluminium phosphide tablets. Aluminium phosphide tablet was taken and scratched using spatula. Small amount of powder was collected and placed it on a piece of cloth. Below the cloth, Whatman's filter paper was placed. Cloth containing powder was folded and tied with rubber band. A beaker (1ltr) full of distilled water was taken and the folded cloth containing Aluminium Phosphide powder was dipped. Bubbles arises, this indicates that gas is liberated into the water. Gas burette containing a hole at the top was inverted over the cloth containing Aluminium Phosphide powder, in a beaker. Later few bubbles were allowed to pass out through the hole of the gas burette and the hole was closed using rubber septum. The whole setup was left for 15 minutes. After 15 minutes a gas layer was formed at the top of the gas burette. The gas layer formed was collected through micro syringe for the experiment. Each tablet liberates about 1.2 liters of gas. (Figure 1a). Twenty adults of newly emerged beetles were introduced into the desiccator (6 litre capacity).
A known volume of phosphine gas was injected into the desiccator (containing 10 pairs of the test population of the beetles) through the rubber septum with the help of gas tight Hamilton syringes. Silicon's wax was applied to all the joints to prevent the leakage of Phosphine gas (Figure 1b, 1c and 1d). The test population of the beetles was subjected to starvation for one hour before exposing to graded concentrations of Phosphine for 24 hours. The concentrations tested were 200ppm, 150ppm, 100ppm, 50ppm and 25ppm. Three replications were maintained for each concentration. Control was maintained without the fumigant. Mortality was observed after 24 hours. The experiment was repeated with varied concentrations of Phosphine to get mortality in the range of 10 – 100%. The mortality data were subjected to probit analysis.

Phosphine Fumigation – Field trial: To find out the effectiveness of Phosphine against all life stages of *S. anale,* fields experiments were conducted at ITC Timber depots in Bhadrachalam. Subabul logs, highly infested with *S. anale* were stacked in the form a cube of 4x4x4 ft. One end of a gas liner (6 mm diameter and 3.5 m length) was placed at the centre of the stack. The end of the gas liner was connected to two one way taps through a lead pipe. One tap was used to monitor Phosphine gas concentration with Uniphos Phosphine monitor (0-2000ppm range); the other tap was connected to a glass vial. Ten adult *S. anale* were baited in the glass vial. Near the mouth of the vial, a cotton plug was placed to prevent the beetles moving along the gas liner in to the stack. 24 quickphos tablets of 56% purity were distributed at different spots on the stack. Some were on the floor and others were on the logs. The stack was quickly covered with a poly sheet and the edges were sealed with mud to make it sufficiently gas tight. The tap connected to the vial containing insects was kept open for free movement of Phosphine from the stack into the vial, while the other connected to Phosphine monitor was kept closed. It was opened only at the time of gas measurement and closed again. Response of baited insects and Phosphine concentrations were recorded over 72 hours and were tabulated. (Figure 2). After 72 hours the enclosure was opened; log samples were removed from different levels viz centre, bottom and top and were autopsied and mortality of different stages of the insect like larvae, pupae and adult were observed.

RESULTS AND DISCUSSION

Different concentrations of phosphine were tested against adults of *S. anale* in desiccator tests. The mortality was 75% at 100ppm, 85% at 150ppm, and 100% at 200ppm levels of the gas (Table 1). LC_{50} is calculated and is 61.73 ppm (Table 2). From the results presented in Figure 3, it can be seen that Phosphine fumigation is highly effective against *S. anale* in laboratory conditions.

Field trial: Observations were taken about the response of baited insects against different doses of phosphine (Table 3). After 72 hours, samples of wood logs were removed from different levels of the stack, autopsied, and observations were taken on the effectiveness of phosphine against different developmental stages of the insect like, larvae, pupae and adult. All developmental stages of the insect including the adult were found dead indicating a good penetration of phosphine in to the logs. The residue of Aluminium tablets were found in the form of powder. (Figure 4). Phosphine concentration profiles over a period of 72 hours are presented in Figure 5.To check the effectiveness of phosphine after one month, observations were made on the infestation level of logs. We found powder underneath the logs in one or two places under the stack. Different concentrations of phosphine were tested against adults of *S. anale* in desiccator tests for 24 hour exposure period. The mortality was 75% at 100ppm, 85% at 150ppm, and 100% at 200ppm levels of the gas. The LC_{50} value is calculated and is found to be 61.73 ppm. Zhang [5] reported that a 24-h exposure of *Arhopalus ferus* (Cerambycidae) adults to 200ppm phosphine gave 100% control. Zhang [6] tested 100 and 200 ppm for 12 h and 200 ppm for 24 h in two trials. He reported about 15% survivors from the 12-h treatments (18−23 *Arhopalus ferus* (Cerambycidae) adults per rep, 4 reps). He also reported 98% *Arhopalus ferus* (Cerambycidae) beetle mortality for the 200 ppm/24-h treatments. However, the assessment assumed moribund beetles were dead when they should be considered live. The result of the present study confirms the above finding. In 2008 FIDA (Forest Industry Development Agenda) supported research aimed at better definition of phosphine requirement in direct exposure trials (i.e. no logs present). From the present study, it is understood that phosphine fumigation is highly effective against *S. anale* in field condition for giving 100% mortality within a short period of time. All logs were autopsied at the conclusion of the trial and no insects survived. Observations proved the efficacy of Phosphine against developmental stages like larvae and pupae and the adults. Efficacy of Phosphine against the egg is not tested in the field. To check the residual toxicity, observations were made on the infestation level of logs, after one month. Frass were found underneath the logs in one or two places under the stack. Experiments showed that fumigation with Aluminium Phosphide is highly effective for controlling existing infestation. The thing about fumigation is that it isn't residual, it will kill the pests inside the treated wood, but it does not leave a barrier to protect against re-infestation. In India, though Phosphine is used against stored grain pests, it is not used for fumigation against wood infesting insects. Effect of Phosphine against wood infesting insects is also proved by some workers of other countries. A large number of both laboratory and operational trials have been undertaken over the past 7 years in

Table 1. Laboratory evaluation of Phosphine fumigation against *S. anale*

Dose	% Mortality
200 ppm	100 ± 0 [a]
150 ppm	85 ± 5 [b]
100 ppm	75 ± 5 [c]
75 ppm	53.3 ± 7.63 [d]
50 ppm	45 ± 5 [d]
25 ppm	10 [e]

SEd= 4.1276 CD(.05) = 9.16 CD(.01) = 13.0821 CV% = 8.27
(Mean ± SD represents mean percentage mortality of 3 replicates with 20 individuals each. Means followed by the same alphabet does not differ significantly at 5% level of significance).

Table 2. Dose-mortality response of *S. anale* against Phosphine fumigation

LC_{50}	Fiducial limit		Slope±SE	Intercept± SE	Chi-square(χ^2)
	Lower	Upper			
61.725	54.575	68.898	3.252±0.310	-5.823±0.584	6.913

The Chi-Square value is less than 9.49 (DF= 4) is not significant (P>0.05).

Table 3. Effect of 72-hour Phosphine treatment on the mortality of Larvae, Pupae and Adult stages of *S. anale* and Phosphine concentration profiles

Date	Time	Duration	Reading (ppm)	Response of baited insects
16/11/07	8.00 AM			
	9.00 AM	1 hour	37	Active
	10.00 AM	2hours	60	Moderately active
	11.00 AM	3hours	155	Narcotized
	12.00PM	4hours	270	Narcotized
	2.00PM	6 hours	360	100% mortality
	8.00PM	12hours	940	
17/11/07	8.00AM	24 hours	947	
	8.00PM	36 hours	502	
18/11/07	8.00AM	48hours	472	
	8.00PM	60 hours	308	
19/11/07	8.00AM	72 hours	155	Sample logs were autopsied and found 100% mortality of adult , larvae and pupae

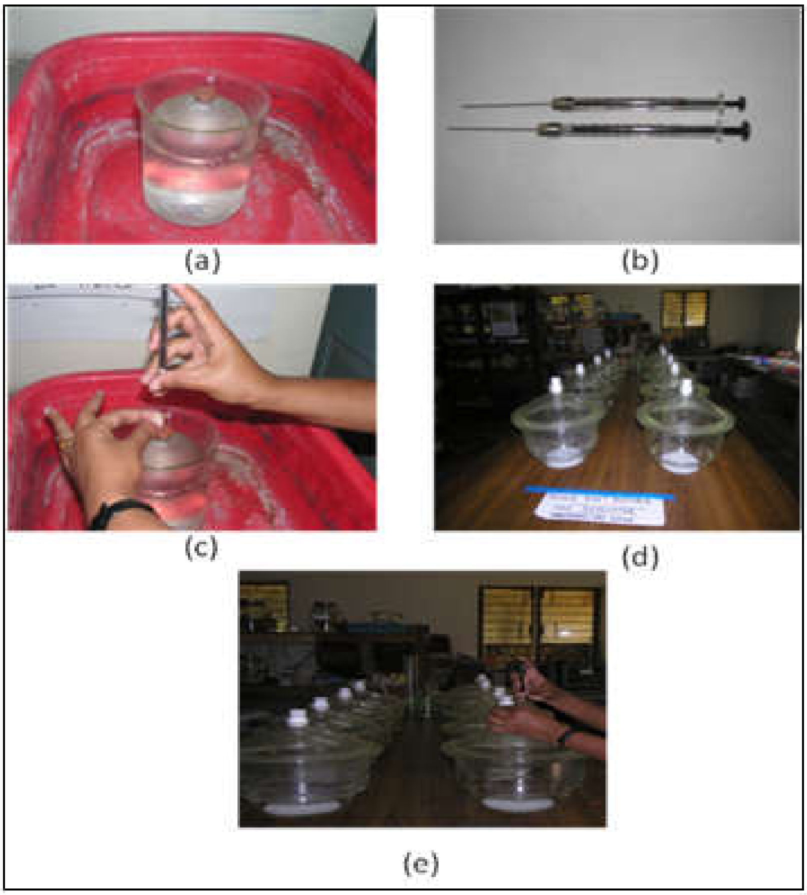

Figure 1. (a) to (e) Phosphine gas preparation and laboratory trails

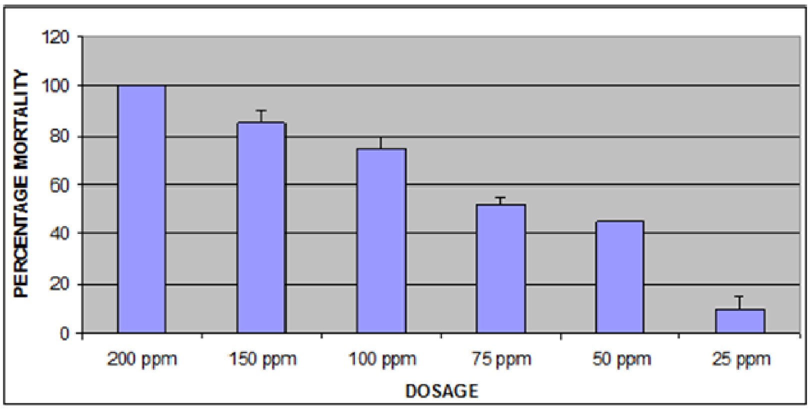

Figure 2. Percentage mortality of S. anale against Phosphine fumigation

Figure 3. (a) - Stack arranged for fumigation, (b) - Covering the stack with poly sheet, (c) - Seal-ing the edges with mud, (d) - Two way pipes, (e) - Baited insects in glass vial

New Zealand on the use of phosphine to control pests likely to be found in radiata pine logs and sawn timber. Research on disinfestation of logs and sawn timber in New Zealand using phosphine has advanced considerably since it began in 2002. In a study made by Li-j *et al*[1]. (1988), *Monochamus sutor*, infesting the logs of *Pinus sylvestris* could be controlled by fumigation with aluminium phosphide (phostoxin) and was the found most effective method. The black pine bark beetle (*Hylastes ater*) and the burnt pine longhorn beetle (*Arhopalus ferus*) are major insect pests of *Pinus radiata* in New Zealand.

In China, transportation of logs with pupae of *Hyphantria cunea* in cracks or holes in the bark was found to be important for spreading the pest around the country. Tests showed that fumigation of logs wrapped in plastic with phosphine at 15−20 g/m3 for 3 days at 25−29°C produced 100% pupal mortality (Shu and Yu) [3]. Oogita *et al.* [2] concluded that phosphine fumigation applied for short periods (48 h) would be unlikely to be an effective quarantine treatment for forest insect pests. They fumigated cerambycids (*Semanotus japonica, Callidiellium rufipenne* and *Monochamus alternatus)*, scolytids

(*Phloeosinus perlatus, Cryphalus fulvus* and *Xyleborus pfeili*) and the platypodids *(Platypus quercivorus* and *P. calamus*) with phosphine at concentrations of 1.0 and 2.0 g/m3 for 24 and 48 h at 15 and 25°C. *S. japonica* and *P. perlatus* eggs were killed at 2.0 g/m3 for 24 h at 15°C, but larvae and pupae of all species were not killed at 2.0 g/m3 for 48 h at 15°C. At 2.0 g/m3 for 48 h at 25°C all stages of *C. fulvus* and *X. pfeili*, except larvae of *C. fulvus*, were killed. The results show that treatment duration must be longer than 48 h to control all life stages of forest insect pests when using phosphine. Wang *et al.* [4] treated poplar timber infested with larvae and pupae of Asian

(a) (b)

Figure 4. (a) and (b) – residue of phosphine tablet after treatment

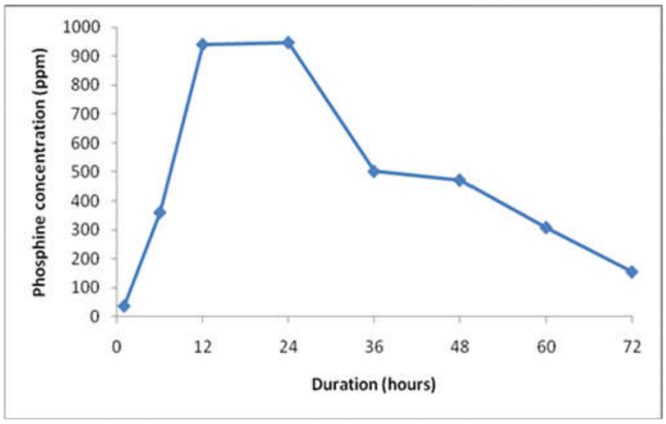

Figure 5. Phosphine concentration profiles during fumigation treatment (Field trial)

longhorn beetle (*Anoplophora nobilis*) and larvae of two other pests with phosphine. Insects were 100% controlled at 15.5°C using a CT of 112 183 mg/h/L in a 120 h (5 day) treatment (i.e. a mean concentration of 935 ppm phosphine). Experiments were carried out to examine the efficacy of the non ozone-depleting fumigant phosphine for eliminating these two pests from *P.radiata* logs at egg, larva and adult life stages. Direct exposure to phosphine at levels as low as 200ppm for up to 10 days has disinfested the three life stages of both pests. Phosphine has the potential to control both pests in export logs before they arrive in the other countries and may be a replacement fumigant for the ozone-depleting methyl bromide (Zhang *et al.,* 2004).

According to the Report of the Methyl Bromide Technical Options Committee by United Nations Environment Programme, fumigation of logs using Phosphine is effective in controlling bark beetles, wood wasps, long horn beetles and platypodids, at a dose of 1.2 gm/m^3 for 72 hour exposure at a temperature of 15 °C or more (Montreal Protocol On Substances that Deplete Ozone Layer, 1998). New developments include phosphine to treat Bamboo in transit to avoid Methyl bromide quarantine treatments in Japan. The present study also confirms the findings of above workers and is a pioneer attempt in these lines in India. So far, studies on the efficacy of Phosphine fumigation against wood borers have been conducted only abroad. The efficacy depends on the leak proof covering of the stacks. If closed fumigation chambers can be created, exposing the logs to fumigants will surely be helpful.

Acknowledgement

The authors are thankful to The Director, IWST, Bangalore, and authorities of ITC, Bhadrachalam, for providing the necessary facilities for carrying out this research work.

REFERENCES

Li, J., Lu, W. D., Shao, J. W., Gao, E. Z., Cheng, W. L. and Lin, G. Q. 1988. Study on Insect pests and their prevention in fire damaged logs in Tahe forest district, China. *Journal of northeast forestry university.,* 16:6, 26-33; 8 ref.

Oogita, T., Soma, Y., Mizobuchi, M., Oda, Y., Matsuoka, I. and Kawakami, F. 1997. Mortality tests for forest insect pests by phosphine fumigation. *Yokohama Plant Protection Station Research Bulletin,* Plant Protection Japan., 38: 17-20.

Shu, C.R. and Yu, C.Y. 1984. A preliminary report on quarantine and experimental control of *Hyphantria cunea* at pupal stage. Forest science and technology-Linye-Keji-Tongzun., No.9, 21-22.

Wang, Y., Zhan, G., Wang, X., Xu Liang., Liu, W., Wu, N., Yang, Y., Sh,i L. and Sun, C. 2003. Primary study on the phosphine fumigation of poplar timber infested with *Anoplophora nobilis*. *Plant Quarantine.,* 17 (13):129-132.

Zhang, Z. 2003. Fumigating export logs using phosphine to eliminate insect pests. *Crop and Food Research Report.,* No. 834.

Zhang, Z. 2004B. Phosphine as a fumigant to control *Hylastes ater* and *Arhopalus ferus pests of export logs. Crop and Food Research report.*

Zhang, Z., Epenhuijsen, C. W., Brash, D. and Hosking, C. P. 2004. Phosphine as fumigant to control *Hylastes ater* and *Arthopalus ferus,* pests of export logs of Newzealand. *Newzealand plant protection*, Vol.57, 257-259,2 ref.

****