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Influence of relative humidity on phosphine concentration during aluminium phosphide (ALP) fumigation in pigeon pea

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Abstract

Phosphine fumigant is widely used to control stored insect pest infestation in grains. The study on Aluminium Phosphide (ALP) fumigation was conducted to find out the effect of relative humidity on concentration of phosphine. Aluminium phosphide (tablet) 56% formulation was used for fumigation of two stacks of pigeon pea grains, each of 4 MT capacities. During fumigation first stack the humidity was ranged 60 to 70% and another stack the humidity was between 50 to 60%. Fumigation procedure carried out as per National Standards of Phytosanitary Measures (NSPM) with dose rate of 3 tablets / MT for 10 days exposure period. Phosphine concentration was monitored in both stacks from 1 to 10 days after fumigation. After 24 hrs (1 day) of treatment the average phosphine concentration was 340 ppm in stack with higher humidity and terminal concentration (after 10 days) was 315 ppm, whereas in stacks with lower humidity the concentration was 309 ppm and 184 ppm after 24 hrs and 10 days respectively. The results revealed that concentration of phosphine was directly proportional to the humidity.

Keywords: Fumigation, phosphine, pigeon pea, concentration, humidity

Introduction

Phosphine (Aluminium phosphide) is one of the significant fumigant (Bell 2000) ^[1] used worldwide for disinfestations of durable commodities and is in use mainly for cereals, pulses and spices (EPPO 2012) ^[2] and other agricultural commodities (Rajendran and Gunasekaran, 1995) ^[3]. Phosphine gas evolved from the tablets or granules effectively controls the various stored product pests in storage (Rajashekar *et al.*, 2006) ^[4]. But the efficacy of the fumigation or released fumigant is directly related to the outside environmental factors *i.e.* temperature and humidity. Numerous pests are associated with food commodities in storage, particularly in the developing countries where poor sanitation practices are followed (Talukder *et al.*, 2004; Talukder 2005; Talukder 2006) ^[5, 6, 7]. Stored grain pests like rice weevil and pulse beetle are widespread and destructive internal feeder of cereals and pulses with the estimated post-harvest loss ranged from 50% and 30-40% respectively (Ahmed 2010) ^[8].

In order to maintain the quality in storage and export of commodities to the international market (Rajendran 2016) ^[9], control of stored product pest is of foremost concern. Phosphine fumigant is widely utilizing to control insect infestation in storage and during the grain trade as a phytosanitary treatment against several insect pests. In India, the grains which meant for consumption is stored in various godowns and warehouses where fumigation is done on regular intervals to protect from pest infestation and supply of insect free products to the consumers. There relative humidity is the crucial factor which decides the success rate of the fumigation (Rajendran *et al.*, 2001) ^[10]. But the information on relationship between humidity and phosphine fumigation is lacking during the monitoring of fumigant concentration. Moreover, the research on phosphine fumigation in presence of relative humidity in varied climatic conditions of India is scanty. Considering the above facts, the present investigation was carried out in field level to determine the effects of relative humidity on release of phosphine with standard concentration by using ALP (tablet) 56 % formulation.

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Materials and Methods

Bagged stacks

The study was conducted with pigeon pea stacks of same batch with 4 MT quantities for 10 days exposure period. The experiment was conducted during the summer months where the humidity was 50 to 60% which was confirmed with the help of digital hygrometer. The humidity was increased artificially for the experiment since the humidity was low. In order to monitor the phosphine concentration in stacks, nylon monitoring lines (NSPM standard) were placed on top, middle and bottom of the stacks as described by (Rajendran *et al.*, 2001) [10]. Further, the stacks were enclosed with standard fumigation sheet to make air tight enclosures.

Treatments and dosage

To check the difference in phosphine concentration in relation to relative humidity, one stack (4MT) were surrounded with wet jute gunny bags before 24 hrs of fumigation where the humidity was increased to 60 to 70% and another stack (4 MT) the natural humidity (50 to 60%) during the experimental period was considered as second treatment. The experiment was replicated thrice. The relative humidity was monitored with the help of digital hygrometer. In both the stacks the dose rate of 3 tablets/MT was applied in 2/3 distribution pattern (two tablets at top and one at bottom of stack) as per NSPM standard 22.

Gas monitoring and leak checking

Three monitoring lines were placed each at front base, middle centre and top back over the enclosures. Phosphine concentration was monitored at 24 hrs interval with phosphine monitor for 10 days (Table 1 and 2); leak checking was monitored at regular intervals using leak detector.

Results and discussion

The study revealed that concentration of phosphine varies gradually with humidity level. It was noticed that commodity with ALP @ 3tablets /MT having 4MT capacities for 10 days exposure periods, the average phosphine concentration ranged from 315-848 ppm (Table 1; Fig.1) with RH 60% and above. 315 ppm is found to be the average minimum concentration. The average phosphine concentration ranged only 184-527 ppm (Table 2; Fig.1) where the RH is 60% and below. Here, 184 ppm is found to be the average minimum concentration. The phosphine gas concentration at initial monitoring after 24 hrs revealed that the average concentration of phosphine was 340 ppm in stack with higher humidity and 309 ppm in stack

with lower humidity. Interestingly, the maximum phosphine concentration was achieved 3rd day after the fumigation in both the stacks *i.e.* 848 ppm and 527 ppm (Fig.1). During 5th day after the ALP treatment the average concentration of 616 ppm and 417 ppm was monitored, at 7th day after the ALP treatment the average concentration of 465 ppm and 315 ppm was achieved in the above stacks respectively. The stacks were perfectly sealed and gas leakage was zero ppm. The statement was in correlation with (Rajendran *et al.*, 2001) [10] they reported that under perfect sealing and covering of stacks with exposure of phosphine achieved maximum concentration and 100% mortality of stored grain pests.

This study was also in line with (Rajendran, 2016) [11] who stated that terminal concentration is one of the important criteria for control of normal and phosphine resistant insects. But here the end concentration of the stack was comparatively low (184 ppm) in the commodity fumigated with humidity range of 50 to 60% whereas the terminal concentration of 315 ppm was achieved in fumigation of commodity with humidity range of 60 to 70%. The experiment conducted by (Reddy *et al.*, 2007) [12] with different food commodities dose at 2g PH₃ per metre cube entrusted the importance of terminal concentration during the fumigation. In present study, the phosphine gas concentration was found increased in relation to the humidity. This investigation has highlighted the importance of relative humidity with regards to phosphine which will be useful for conducting the further studies on increasing the humidity at field level especially during the summer months and dry areas where the humidity is less. Further study on fumigation with monitoring of phosphine concentration with different humidity levels against storage pests especially on insects is needed to achieve greater success in fumigation.

Conclusion

This study concluded that relative humidity has played the major role in releasing the phosphine. As the humidity decreases the concentration or the release of phosphine becomes slow. India, being a tropical country having diversified climatic conditions, the humidity was less in many days in the places away from the seashores. Hence, a detailed study on different levels of humidity during fumigation period is required to develop good fumigation practices. This preliminary study will help in build-up of phosphine concentration which is required to control dreaded storage pests in the commodities.

Table 1: Concentration of phosphine gas on pigeon pea with 60 to 70% relative humidity

Dose / MT	Stack \ Humidity level	Treatment duration	Average phosphine concentration (Values in ppm)
3 tablets	Stack1/RH 60-70%	Day 1	340
		Day 2	706
		Day 3	848
		Day 4	664
		Day 5	616
		Day 6	535
		Day 7	465
		Day 8	419
		Day 9	370
		Day 10	315

Table 2: Concentration of phosphine gas on pigeon pea 50 to 60% relative humidity

Dose / MT	Stack \ Humidity level	Treatment duration	Average phosphine concentration (Values in ppm)
3 tablets	Stack 2 /RH 50-60%	Day 1	309
		Day 2	466
		Day 3	527
		Day 4	513
		Day 5	417
		Day 6	352
		Day 7	315
		Day 8	283
		Day 9	232
		Day 10	184

Note: 1 MT = 1000 kg

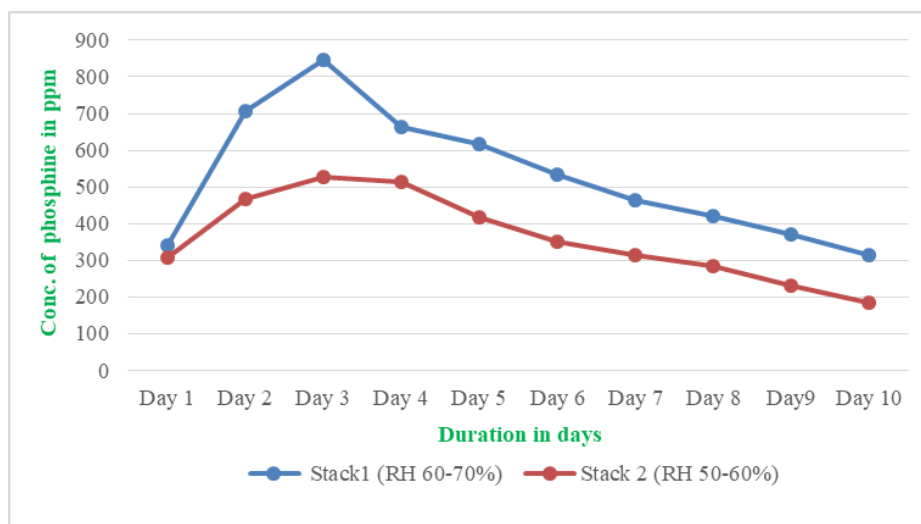


Fig 1: Concentration of phosphine gas on pigeon pea stacks at 10 days exposure period with two different relative humidity

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