Nitrogen based modified atmosphere for the management of Cigarette beetle, *Lasioderma sericorne* in turmeric

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Abstract- *Lasioderma sericorne (F) is a direct pest affecting stored turmeric causing quantitative and qualitative losses. While other management methods have different side effects on the environment and human health, there is a need of eco-friendly methods to manage the pests. Manipulation of the atmosphere to control stored product insects has a promising future. Studies were conducted to determine the effectiveness of nitrogen based modified atmosphere on Lasioderma sericorne population. The experiments was conducted with different ratios of gases (N_2:CO_2:O_2) with exposure period (24, 48, 72, 96 and 120 hrs) and the treatments were replicated 3 times. The results showed that insect mortality increased by increasing the N_2 concentration or by extending the exposure period to N_2. In addition adult population decreased drastically while high concentration of nitrogen. Larva and pupa were seems to be tolerant requires.*

Keywords- Modified atmosphere, Nitrogen gas, *Lasioderma sericorne*, life stages, mortality

I. INTRODUCTION

Turmeric (*Curcuma longa*) is a rhizomatous herbaceous perennial plant native to southeast India. India is a largest producer of turmeric in world (Peter 1997). India account for about 78% of world turmeric production with the turmeric production of 10625.5 tones (DES, 2012). Turmeric is severely damaged by the insect, Cigarette beetle, *Lasioderma sericorne* .L and drug store beetle, S*tegobium paniceum* F. (Pruthi 1980)**.** Management of turmeric using chemical methods has side effects on the environment. Manipulation of the composition of the atmosphere to manage stored product insects has a promising future (Bailey, 1956). This modified atmosphere storage has many advantages compared to conventional methods of storage (Calderon and Barkai-Golan, 1990). It provides a way to eliminate insects from stored commodities without polluting the atmosphere and safer traditional fumigants. No harmful residues remain after the treatment of the commodity with nitrogen (N_2) or oxygen (O_2). Atmospheres which could be utilized for this purpose in grain storage are those with reduced O_2 and those with increased CO_2 content or a combination of the two. Means of producing such atmospheres include the purging of airtight silos with N_2 from tankers and the elimination of O_2 using burners or catalytic generators (Navarro, 2006). Navarro (1986), Banks and Annis (1990) stated that N_2 causes a progressive hypoxia or anoxia when used alone at a high purity level. Generally the lower the O_2 level, the higher the mortality. For effective control, the O_2 level should be less than 3 % and preferably less than 1 % if a rapid kill is required. It is known that modified atmosphere is frequently practiced in developed countries (Longstaff, 1994). There is a need to study the effect of gases on turmeric pests. It leaves no toxic residues in the treated turmeric are safer to consume. Keeping all these points in view, the present study was initiated to evaluate the effectiveness of nitrogen based modified atmosphere on *Lasioderma sericorne*.

II. MATERIALS AND METHODS

2.1. Maintenance of insect culture

The experiment was conducted in 2015 at the storage entomology laboratory of Indian Institute of Crop Processing Technology, Thanjavur, Tamil Nadu. Fresh turmeric was procured from Erode farmer's field. Stored pests and their stages were maintained in rearing cage at a room temperature of 30 ^oC and 70 ± 5% relative humidity (RH) throughout the period of study. For getting uniform aged adults, 100 g of fresh turmeric was exposed to 10 pairs of insects and allowed for one to two days for egg laying. All the adult insects were removed after 1-2 days and uniform aged adults were harvested 25 days after egg laying.

2.2. Design of Airtight acrylic bin for treating turmeric under modified atmosphere

Lab model CO_2 fumigation setup was designed and fabricated at Indian Institute of Crop Processing Technology, Thanjavur. It consists of circular outer acrylic cylindrical tube with the dimension of 37 x 27 cm (ht x dia) which is pasted in a flat acrylic tube at the bottom. At the top cover of the fumigation chamber, PVC end cap was used to make the set up air tight and suitable for modified atmospheric fumigation. Provision for gas inlet and outlet were also given to maintain the required concentration of gases. Preliminary studies were done to check the air tightness of the container. Known concentration of gas mixture (CO_2, O_2 and N_2) from the pressurized cylinders was flushed into the acrylic bin. N_2 gas concentration such as 40, 50, 60, 70 and 80 % was used and were kept for 24, 48, 72, 96 and 120 hrs. The bin was kept for one day and the gas level was checked again with the help of O_2 analyzer to confirm the gases initial level. Ten numbers of 1-2 days old beetles were transferred to the acrylic bin and N_2 gas from cylinder was introduced. While purging N_2 gas, the outlet port was kept open to flush out the air from the container at the time of treatment. After injecting the N_2 gas, the inlet and outlet ports were closed.

III. RESULTS AND DISCUSSION

Controlled Atmosphere is a modified gas composition, usually produced artificially and maintained unchanged by adding desired gases (CO_2 or N_2), supplied from pressurized cylinders or by other means. This supplementary introduction of gases is carried out when their concentration in the sealed container drops below the desired level. The objective of CA treatment is to attain a composition of atmospheric gases rich in N_2, CO_2 and low in O_2, or a combination of these three gases within the storage enclosure or treatment chamber. These set concentrations are maintained for the time necessary to control the storage pests. A widely used source for production of such atmospheric gas compositions is tanker - delivered liquefied CO_2 or N_2.When the target CA gas composition is < 1% O_2 or high CO_2 concentration.

The results of the Table 1 shows the effect of N_2 based modified atmosphere on the life stages of cigarette beetle. The adult and pupa mortality was found to be high in all the treatments than larva. When compared to other stages larval stage was highly resistant requires long exposure time. At 40 % N_2 with 24 h exposure period, 100 per cent pupa mortality was observed. Even with high concentration of 80 % N_2, only 55 and 74 per cent larva and adults were dead (Table.1). At 72 hrs and 60 % N_2, 100 per cent mortality of adult and pupa were observed, while the larval mortality was 77 %.

Maximum larval mortality was noticed in gas combination containing 50 and 60 per cent N_2 with 120 h exposure period. Along with N_2 and O_2 presence of CO_2 is also essential which cause suffocation in insects results in quick mortality. Based on the present study minimum CO_2 concentration of 20% is essential for the management of cigarette beetle elevated CO_2 levels cause spiracle to open resulting in insect death from water loss. Above 10% CO_2 spiracles remain permanently open. Toxic effects are entirely through the tracheae, not the haemolymph; CO_2 has direct toxic effects on the nervous system (Navarro *et al.* 1985).

Insects can tolerate low levels of oxygen for prolonged periods. Using N_2 to replace O_2 is must result in O_2 being below 2%, preferably 1% for rapid death. This effect is reversed below 1% O_2 in N_2 where adult rice weevils, *Sitophilus oryzae* (L.) showed tolerance, increasing the lethal exposure time by apparently closing their spiracles. In particular, *S. oryzae* adults were killed more quickly at 1.0% O_2 rather than at 0.1 or 2% O_2 under the same conditions. *Tribolium castaneum* (Hbst.) in N_2 showed significant differences in adult mortality between 0.1 and 1.0 % O_2. Adults were generally most susceptible to treatment. In case of *S. oryzae* and *Rhyzopertha dominica* (F.) more than tolerant *Tribolium* sp. Annis (1987) concluded that O_2 levels of 1% are needed to kill insects in 20 days for the stored pest. From the present study use of modified atmosphere containing (50:10:40 & 60:10:30 percent N_2:O_2:CO_2) seems to be effective for the management of *Lasioderma sericorne* in turmeric.

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Table 1. Effect of nitrogen based modified atmosphere on adult mortality of *L. sericorne at* 24 h

S. No	Fumigation gas ratio (N_2:O_2:CO_2)	Percentage of adult mortality	Percentage of larval mortality	Percentage of pupa mortality
1	40:10:50	53	30	100
2	50:10:40	58	36	100
3	60:10:30	66	40	100
4	70:10:20	69	48	100
5	80:10:10	74	55	100

Table 2. Effect of nitrogen based modified atmosphere on adult mortality of *L. sericorne at* 48 h

S.No	Fumigation gas ratio (N_2:O_2:CO_2)	Percentage of adult mortality	Percentage of larval mortality	Percentage of pupa mortality
1	40:10:50	72	66	100
2	50:10:40	81	20	100
3	60:10:30	100	66	100
4	70:10:20	66	46	100
5	80:10:10	33	20	100

Table. 3. Effect of nitrogen based modified atmosphere on adult mortality of *L. sericorne at* 72 h

S.No	Fumigation gas ratio (N_2:O_2:CO_2)	Percentage of adult mortality	Percentage of larval mortality	Percentage of pupa mortality
1	40:10:50	100	100	100
2	50:10:40	100	55	100
3	60:10:30	100	77	100
4	70:10:20	100	46	100
5	80:10:10	45	33	100

Table 4. Effect of nitrogen based modified atmosphere on adult mortality of *L. serricorne* at 96 h

S.No	Fumigation gas ratio (N_2:O_2:CO_2)	Percentage of adult mortality	Percentage of larval mortality	Percentage of pupa mortality
1	40:10:50	100	100	100
2	50:10:40	100	83	100
3	60:10:30	100	77	100
4	70:10:20	100	66	100
5	80:10:10	53	40	100

Table5.Effect of nitrogen based modified atmosphere on adult mortality of *L.serricorne* at 120 h

S. No	Fumigation gas ratio (N_2:O_2:CO_2)	Percentage of adult mortality	Percentage of larval mortality	Percentage of pupa mortality
1	40:10:50	100	100	100
2	50:10:40	100	91	100
3	60:10:30	100	100	100
4	70:10:20	100	100	100
5	80:10:10	66	50	100