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Effect of cow dung smoke on pulse beetle, *Callosobruchus chinensis* (Linn.) and quality parameters of stored pulses at Pantnagar, Uttarakhand

Kamal Kishor, Bhabani Mahankuda and Ruchira Tiwari

Abstract
A bioassay study was conducted on the effect of cow dung smoke on mortality of pulse beetle, *Callosobruchus chinensis* (Linn.) and on quality parameters of stored pulse commodities *viz.* mung bean, urd bean, chickpea and pigeonpea under laboratory conditions in the Department of Entomology, G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand during 2018. The results showed that more than 50 per cent insect mortality was observed on pulse seeds after 96h to 120 h of exposure to cow dung smoke whereas without smoke the overall mean mortality of pulse beetles was 2.22, 4.99, 6.94 and 11.38 after 48, 72 h 96h and 120h, respectively of insects confinement under airtight conditions on different pulse commodities. The data clearly showed that the overall mean mortality of pulse beetle on different stored pulses was increased to four times with smoke treatments at different intervals of exposure periods. On the other hand, cow dung smoke had no adverse effect on different quality parameters of seeds after different exposure periods which depicted that the overall mean germination of pulse commodities was not affected by smoke exposure from 1h to 120h of a time interval as it was ranged from 85.83 to 87.91 with germination index (7.35 to 7.53), root length (13.20cm to 14.23cm), shoot length (12.81 to 13.75), vigour index (2289.11 to 2429.66), significance of viability (0.97 to 0.99) which was quite similar to the overall mean values per cent germination (87.91) germination index (7.53), root length (13.80cm), shoot length (13.75cm), vigour index (2423.33) and significance of viability (1.00) as observed in untreated pulses commodities. Therefore, the present study revealed that cow dung smoke was found lethal to pulse beetle but has no deleterious effects on seed quality of pulse commodities under storage conditions.

Keywords: *Callosobruchus*, cow dung , pulse beetle, stored pulses, smoke

Introduction
Pulses belong to the legume family Fabaceae or Leguminosae, under the sub-family Papilionaceae. The pulses like mung bean, urd bean, moth bean, chickpea, pigeon pea, lentil, pea, etc. are grown in India. In developing countries like India, and worldwide, pulses are the major source of protein for the daily diet of low-income groups of people and vegetarians (Prasantha *et al.*, 2003) [20]. India is the largest producer, importer and consumer of pulses, accounting for 25% of global production from 35% of the global area under pulses. (IIPR, 2016-17).They contain 20 to 30% of protein which is almost three folds higher than cereal crops (Ahmed *et al.*, 2016).

These legume seeds are susceptible to pulse beetle, and is a serious, most destructive, cosmopolitan and polyphagous pest of stored pulses feed on bean, cowpea, urd bean, mung bean, lentil, chickpea or other legume grains (Mishra *et al*, 2015) [17]. Bruchids (pulse beetle) belong to the family Bruchidae that comprises more than 1700 species of 62 genera worldwide (Romero and Johnson, 2004) [23]. In India, among the insects which infest various pulses is *Callosobruchus chinensis* (Linn.). (Sarwar, 2012) [24], *Callosobruchus maculates* (Fab.) (Jadhav *et al.*, 2012) and *Callosobruchus analis* (Fab.) (Deeba *et al.*, 2006) [7]. The genus C*allosobruchus* has been reported to be a serious pest in the middle and Far East, Africa and India. It is cosmopolitan in distribution and reported to cause serious damage to pulses in India and many countries of the globe. It is recorded that 55- 60% loss in seed weight and 45.50 to 66.30% loss in protein content of pulses is due to infestation caused by this beetle (Faruk *et al.*, 2011) [9].

All over the world, management of this devastating stored insect pest, pulse beetle, has solely relied on the application of synthetic chemicals and fumigant insecticides such as methyl bromide and phosphates, which have been taken as the most effective and quickest means of protection for stored food and agricultural commodities from insect infestation (EPA, 2001) [8]. But despite the quick action of these synthetic products, their intensive use causes many problems such as the occurrence of insect resistance, accumulation of residues in foods (Fishwick, 1988) [10], human health hazards, and environmental contamination (Campo *et al*., 2013) [6]. It has been reported a long back that the pulse beetle has developed resistance to malathion (Singh and Srivastava, 1983) [27]. Many stored grain pests have developed resistance to phosphine (Bell and Wilson, 1995; Sayaboc *et al*., 1998; Daglish and Collins, 1999; Rahman and Shajahan, 2000; Benhalima *et al*., 2004) [25, 5].

To avoid the injudicious use of synthetic chemicals the naturally produced smoke has a great potential for causing insect mortality (Srivastava *et al*., 2005) and promoting seed germination and enhancing plant growth (Yadav and Tiwari, 2018) [33]. This easily accessible technology is a good substitute for hazardous chemicals and can easily to adopt by the users without having any adverse effects on stored pulse grains and human health. Keeping all these facts in mind the present study was made to quantify the possible effect of smoke generated by the burning of cow dung cake on mortality of pulse beetle and quality of seeds of stored pulse commodities under airtight conditions.

Materials and Methods

Collection of materials and Production of Smoke

The seeds of Gram (Chickpea) variety PG-186, Black gram (Urd bean) variety PU-31, and Green gram (Mung bean) variety PM-5 were taken from Department of Genetics and Plant Breeding, G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand during 2018. The cow dung cakes were collected from desi breed cows from the nearby houses domesticating cows. Smoke was produced by burning dried cow dung cake in a smoker and aerosol smoke was collected for further process. The insect culture of test insects *viz. Callosobruchus chinensis* was obtained from the stock culture prepared on stored pulses (Chickpea, Urd bean, and Mung bean) in the laboratory of the Department of Entomology, College of Agriculture, GBPUA&T Pantnagar, Uttarakhand.

Bioassay on the effect of smoke on the mortality of test insects

The laboratory bioassay were conducted on the effect of smoke generated by burning of cow dung cake, on the mortality of adult pulse beetle of *Callosobruchus chinensis* by releasing 50 insects each, separately in conical flasks in three replications (Total number of insects =150) containing 5 gram of pulse seeds. After releasing insects, smoke was filled in conical flasks by burning of cow dung cake, separately with the help of smoker and opening of the conical flasks were tightly closed with cotton plugs. The experiments were set up separately for different interval of time i.e.1, 6, 12, 24, 48, 72, 96 and 120 hours to find out the effect of smoke on the tested insect under smoke exposure for different periods.

Effect of smoke on seed quality parameters at different exposure time interval

The effect of smoke generated by cow dung cake on quality of pulse seeds (Chickpea, Urd bean, and) Mung bean was studied on the parameters of germination and post germination response of treated pulse seeds. The pulse seeds were kept in conical flasks treated with cow dung smoke for different exposure periods under airtight conditions. The effect of smoke on seed quality was assessed on different quality parameters by using Germination assay. Germination assay was conducted to find out the effect of smoke on the germination and post germination quality parameters. The pulse seeds were kept in conical flasks treated with cow dung smoke separately for different exposure periods under airtight conditions. Germination assay was done separately for all treated pulse commodities as mentioned above. The seed germination tests was carried out employing rolled paper towel test according to International Rules of Seed Testing (Anonymous, 1985) [4]. The germinated seeds were counted after 7-8 days and length of shoots and roots were measured along with calculation of vigour index and significance of viability. Then, seed germination percentage, germination index, vigor index were calculated and seedling root and shoot length were also measured. Germination index was calculated using a formula designed by (ISTA, 2010) [12] and seedling vigor index was calculated by using an equation designed by Abdul baki and Anderson, (1973) [1].

$$\text{Total Germination} = \frac{\text{Per cent seeds germinated} \times 100}{\text{Total no. of seeds planted}}$$

$$\text{Germination Index(GI)} = \frac{\text{No. of seedlings emerged on day (n)}}{\text{Days after planting (d)}}$$

Vigor Index (VI) = Per cent germination x (root length + shoot length)

$$\text{Significance of viability (SV)} = \frac{\text{Percent germination in treated grain}}{\textit{per cent} \text{ germination in control}}$$

Statistical analysis

Data were subjected to Complete Randomized Design (CRD) after suitable transformations. The per cent data was subjected to angular transformation before statistical analysis. Similarly, the data based on mean number of insects were undergone square root transformation with X+0.5 adding factor.

Results and Discussion

Effect of cow dung smoke on the mortality of adult pulse beetle on different pulses

The data recorded on the effect of cow dung smoke on insect mortality of adult pulse beetle *Callosobruchus chinensis* on mung bean and urd bean is presented in Table 1. The cow dung smoke was not found lethal to pulse beetle after one hour of exposure as no insect mortality was observed in exposure to cow dung smoke whereas 1.11 per cent mortality of *C. chinensis* adult beetle was observed after 6 hours of exposure to smoke. The insect mortality was increased with the increase in exposure period of cow dung smoke under airtight conditions as per cent mortality 3.33, 4.44, 11.11, 31.10, 45.55, 54.44 of pulse beetle was observed after 12, 24, 48, 72, 96, 120 hours of exposure of cow dung smoke. In comparison to under airtight conditions without smoke on mung bean no adult beetle mortality has occurred after 1, 6, 12 and 24 h of exposure whereas 2.22 , 5.55, 6.67 and 10.00

per cent mortality of adult beetle was observed after 48 h, 72 h, 96 h and 120 h of airtight conditions without smoke, respectively .

Similarly, the effects of cow dung smoke on insect mortality of *C. chinensis* on urd bean is presented in Table-1 which again showed that **t**he cow dung smoke was not lethal to pulse beetle as no mortality was observed after one hour of exposure to cow dung smoke whereas 1.11, 2.22, 3.33 and 8.88 per cent mortality of adult pulse beetle was observed after 6 h,12h, 24h and 48h of exposure to smoke, respectively. The drastic increase in insect mortality 25.55 per cent was recorded after 72 h of exposure to cow dung smoke followed by 32.21 per cent mortality of pulse beetle observed after 96 h of exposure with the highest 44.44 per cent insect mortality was observed after 120 h of exposed to smoke. In comparison to under airtight conditions without smoke on urd bean no adult pulse beetle mortality has occurred after 1 h, 6 h, 12 h and 24 h whereas 2.22, 3,33, 5.55 and 11.10 per cent mortality of *C. chinensis* adult beetle was observed after 48 h, 72 h, 96 h and 120 h on urd bean grains.

The effect of cow dung smoke on the insect mortality of pulse beetle, *C. chinensis* on chickpea and pigeonpea seeds are presented in Table 2. The cow dung smoke was not killed adults of pulse beetle after one hour of exposure but 2.22 per cent mortality of adult beetles was observed after 6 h and 12 h of exposure to smoke followed by 4.44 per cent and 6.66 per cent mortality of pulse beetle was observed after 24 h and 48 h of exposure, respectively. The cow dung smoke proved lethal to pulse beetle after 72 hours of exposure as it caused 21.10 per cent mortality followed by 36.66 per cent mortality after 96 hours of exposure with significantly highest 46.66 per cent mortality of pulse beetle was observed after 120 hours of exposure. In comparison to under airtight conditions without smoke on chickpea no adult pulse beetle found dead under airtight conditions without smoke after 1 hour, 6 hours, 12 hours and 24 hours whereas 1.11, 6.66 and 10.00 per cent mortality of *Callosobruchus chinensis* adult beetle was observed after 48 hours, 72 hours and 96 hours of insects confinement under airtight conditions on chickpea grains.

Overall mean adult mortality of pulse beetle, *C. chinenesis* with /without smoke under airtight conditions in pulse commodities

The data presented in **Table-3** depicted the effect of cow dung smoke on the overall mean mortality of pulse beetle, *C. chinensis* in different pulse commodities under different exposure periods. After one hour of exposure to smoke, there was no mortality occurred in adult pulse beetles, whereas 1.38 per cent mortality of *C. chinensis* adult beetle was observed after 6 h of exposure to smoke followed by 2.77 and 3.88 per cent mortality of pulse beetle was observed after 12 h and 24 h of exposure with 8.60 per cent mortality observed after 48 h of exposure to smoke. The per cent mortality of pulse beetle was drastically increased to 24.99 per cent after 72 h of exposure, followed by 39.71 and 48.05 per cent mortality was observed after 96 h of exposure to cow dung smoke.

The overall mean mortality of *C. chinensis* was calculated on different pulses under airtight conditions without smoke at different interval of time period and the related data is presented in Table-3. No insect found dead under airtight conditions without smoke after 1 h and 6 h, whereas overall mean adult mortality was calculated (0.27 and 0.55) after 12 h and 24 h interval of time. The overall mean adult mortality of pulse beetles was calculated 2.22, 4.99, 6.94 and 11.38 after 48, 72 h 96h and 120h of insects confinement under airtight conditions on different pulses.

The data clearly showed that the overall mean adult mortality of pulse beetle, *C. chinensis* on different stored pulses was increased to four times with smoke treatments at different intervals of exposure periods.

Effect of Smoke on quality parameters of seeds under different exposure period

The pulse commodities (mungbean, urd bean, chickpea and pigeonpea) were treated with cow dung smoke for different exposure periods for their germination and post germination response. The data given in Tables-4 and 5 showed the effect of cow dung smoke on the quality of pulse seeds at different exposure periods. Both treated and untreated seeds indicated variability in germination percentage, germination index, seedling vigor index, root and shoot length in response to smoke treatments. The data presented in Table-4 presented the per cent germination, germination index and mean root length of smoke treated pulse commodities, which clearly revealed that no significant difference was observed in per cent germination of all four smoke treated pulse grains i.e. mung, urd, chickpea and pigeonpea after different exposure periods. The germination was ranged between 85.00 to 91.66 per cent among the all smoke treated pulse seeds with 85.00 to 90.00 per cent germination was observed among the all untreated pulse seeds. Similarly, under different exposure periods, among the smoke treated pulse seeds, no significant difference was observed in germination index values which was ranged between 7.28 to 7.85 which was calculated more than the germination index values calculated 7.28 to 7.71 in all untreated pulse seeds.

Similarly, among the different exposure periods of mung bean seeds to cow dung smoke, the mean root length was recorded the highest (16.96cm) after 1 h smoke exposure whereas among the other treatments mean root length was ranged from 16.35cm to 15.35cm with the least mean root length (14.65 cm) of mung bean seeds was measured after 12 h exposure to smoke. The mean root length of untreated mung seeds was measured 15.68cm. The mean root length of smoke treated urd bean seeds was measured more *i.e.* 15.76 cm, 15.64cm, 15.54 cm and 15.32 cm after 72 h, 24 h, 1 h and 48 h of smoke exposure, respectively. Among the other treatments, mean root length was ranged from 14.60cm in 120 h of smoke exposure to 14.95cm in untreated urd bean seeds. The highest mean root length of smoke treated chickpea seeds was measured after 48h of smoke exposure (13.69 cm) whereas among the other treatments it was ranged from 12.57 cm to 13.62 cm along with the least mean root length (12.38cm) of chickpea seeds was measured after 12 h of exposure to smoke. Among the smoke treated pigeonpe seeds, the highest mean root length (11.68cm) was measured after 96 h of smoke exposure whereas among the other treatments it was ranged from 10.85cm to 11.65cm with the least mean root length (11.20cm) was recorded in untreated pigeonpea seeds.

The data of to the mean shoot length, vigour index and significance of viability of smoke treated pulse commodities is presented in Table-5. The mean shoot length of smoke treated mung bean seeds was recorded the highest (17.65cm) after 1h smoke exposure whereas among the other treatments mean shoot length was ranged from 15.64cm to 16.84cm with the least mean shoot length (15.34 cm) of mung bean seeds was measured after 96 h exposure to smoke. The untreated mung seeds showed 16.92cm of mean shoot length. Similarly,

among the different exposure times of urd bean seeds to cow dung smoke, the shoot length ranged from 11.35 cm in 24 h exposure time to 12.84 cm after 120 h of smoke exposure to urd bean seeds with mean shoot length of 12.65cm was measured in untreated urd bean seeds. Among the different exposure times of chickpea seeds to cow dung smoke, the highest shoot length (12.15cm) was measured after 120 h followed by 24 h of exposure. The least mean shoot length (10.62cm) was measured after 6h exposure to smoke. Among the smoke treated pigeonpea seeds, the shoot length ranged from 11.68 cm to 13.85 cm with the least shoot length (11.64cm) measured after 48 h of exposure time under airtight conditions.

The root length and shoot length along with per cent germination of treated mung seeds gave vigour index values which were found the highest (3057.10) after 1 h exposure of mung seeds to cow dung smoke whereas among the other treatments the vigour index was ranged from 2702.01 to 2879.55. The values for significance of viability were calculated (1.00) for the cow dung smoke treated mung bean seeds after 1, 6, 12, 48, 72 and 120 hours of exposure which was similar to the significant of viability values calculated for untreated mung bean seeds with slightly less (0.98) was recorded in mung bean seeds after 24 and 96 hours of smoke exposure.

The values for vigour index were calculated for smoke treated urd bean seeds which was recorded the highest (2476.77) after 1 h of exposure followed by 2461.14 and 2423.77 after 72 h and 120 h of exposure of urd bean seeds to cow dung smoke, respectively. The vigour index value (2437.90) was calculated for untreated urd bean seeds with the least vigour index (2312.00) was observed in 12 h of exposure to urd seeds. The significance of viability was calculated the highest (1.00) for the cow dung smoke treated urd bean seeds after 1 hour and 120 hours of exposure and untreated urd bean seeds whereas among the other exposure time intervals it was varied from 0.96 to 0.98. For smoke treated chickpea seeds the vigour index values were calculated the highest (2193.36) after 48 h exposure of chickpea seeds to cow dung smoke followed by (2148.30) after 120 h of smoke exposure and 2140.30 in untreated chickpea seeds followed by vigour index (2122.30) of chickpea seeds after 1 hour of exposure to smoke. Among the other treatments, vigour index values were ranged from 1977.95 to 2098.90.The value for significance of viability was calculated the highest (1.01) for the cow dung smoke treated chickpea seeds after 1, 12, 48, 96 and 120 h of exposure whereas it was calculated (1.00) in untreated chickpea seeds and smoke treated chickpea seeds after 6, 24, 72 h of exposure under airtight conditions. The smoke treated pigeon pea seeds gave the highest vigour index value (2264.00) after 72 h of exposure whereas among the other treatments, vigour index was ranged from (2001.75) calculated after 24 h exposure of pigeon pea seeds to 2235.60 in untreated pigeon pea seeds. The significance of viability was calculated the highest (1.01) for the cow dung smoke treated pigeon pea seeds after 72 and 96 h of exposure whereas among the other exposure times it was varied from 0.96 to 1.00.

Overall effect of cow dung smoke on quality parameters of pulses seeds under airtight conditions

The overall effect of cow dung smoke on germination and post germination response of different pulses commodities under different exposure time intervals *i.e.* 1, 6, 12, 24, 48, 72, 96 and 120 h. was observed under airtight conditions. The overall mean data related to the effect of exposure of cow dung smoke on quality parameters of different pulses commodities for different time intervals is given in Table-6 **,**which clearly depicted that the overall mean germination of pulses commodities was not affected by smoke exposure from 1h to 120h of time interval as it was ranged from 85.83 to 87.91 with germination index (7.35 to 7.53), root length (13.20cm to 14.23cm), shoot length (12.81 to 13.75),vigour index (2289.11 to2429.66), significance of viability (0.97 to 0.99) which was quite similar to the overall mean values per cent germination (87.91) germination index (7.53),root length (13.80cm), shoot length (13.75cm), vigour index 2423.33 and significance of viability (1.00) as observed in untreated pulses commodities. This clearly proved that cow dung smoke at different exposure periods has no any deleterious effects on seed quality of pulses commodities.

Smoke is the cheapest and easily available source of Carbon dioxide (CO_2). In Indian villages kitchen smoke has been used from long ago to protect seeds from insect pests from one season to another. CO_2 has been used for killing insects in stored products (White *et al.*, 1990) [32]. Many stored grain pests have developed resistance to phosphine (Sayaboc *et al.*, 1998; Benhalima *et al.*, 2004) [25, 5]. Similar studies were also made by several workers on the efficacy of CO_2 under modified environmental conditions against storage insect pests. Novaro and Riudavates *et al*., (2006) [22] were carried out research on modified atmosphere with CO_2 on various storage pests including beetle pests and moths. Rathi *et al*., 2000 [21] reported that red gram seeds exposed to CO_2 showed less insect infestation, less mould attack and high per cent germination. Sinha *et al*,.(2001) [28] evaluated efficacy of smoke generated by burning cow dung cake containing 4% CO_2 gave 31.5, 32.0, 37.8, 57.8 and 80.0 per cent mortality of adult *Callosobruchus maculatus* at 24, 48, 72, 96 and 120 h exposure, respectively. Shazali *et al*., (2004) [26] also reported that complete mortality of eggs of *C. maculatus* could be achieved by CO_2 treatment under pressure. Yadav and Mahla, (2005) [33] investigated the efficacy of biogas and found it very effective against *R. dominica, Corcyra* Srivastava *et al.*,(2006) [30] reported, more than 80 per cent, mortality of pulse beetle, *C. maculatus* at 24 h exposure of cow dung cake smoke. Mann and Srivastava, (2013) [15] evaluated the effect of smoke generated by burning of different parts (root, stem, leaf and fruit) of plant, *Aerva tomentosa* and found 40 -50 per cent adult mortality in *R. dominica* after 48 h of treatment. Iqbal *et al.*, (2016) [11] reported the positive and stimulator effect of plant derived smoke on germination percentage, germination index, seedling vigor index and root shoot length of wheat seeds for 1 h exposure period. Padmsri *et al*., (2017) [19], studied the effect of elevated levels of CO_2 on pulse beetle *C. chinensis* in stored redgram and suggested that 40% and 50% CO_2 are more toxic to *C. chinensis* and can be recommended for long term storage of redgram seed. Yadav and Tiwari, (2018) [33] reported that more than 50 per cent mortality of stored grain insect pests was observed after 72h and 96h of exposure to cow dung and neem leaf smoke. A positive effect of cow dung and neem leaf smoke was also observed in enhancement of the seed germination with more root and shoot length of treated wheat seeds which ultimately gave high vigour index and significance of viability.

Table 1: Effect of cow dung smoke on mortality of pulse beetle, *C. chinensis* in mungbean and urd bean at different time intervals

S. No.	Treatment	Per cent adult mortality of pulse beetles in pulses commodities															
		Mung bean								Urd bean							
		At different time intervals of smoke exposure (hour)															
		1	6	12	24	48	72	96	120	1	6	12	24	48	72	96	120
1.	Smoke	0.00	1.11	3.33	4.44	11.11 (19.42)*	31.10 (33.87)	45.55 (37.18)	54.44 (47.55)	0.00	1.11	2.22	3.33	8.88 (17.10)*	25.55 (29.58)	32.21 (41.78)	44.44 (41.80)
2.	Untreated Control (without smoke)	0.00	0.00	0.00	0.00	2.22 (9.99)	5.55 (21.27)	6.67 (20.91)	10.00 (26.97)	0.00	0.00	0.00	0.00	2.22 (10.76)	3.33 (18.61)	5.55 (23.90)	11.10 (25.06)
	SEm±	-	-	-	-	0.012 (0.169)	0.008 (0.037)	0.651 (0.384)	0.492 (0.432)	-	-	-	-	0.063 (0.035)	0.657 (0.381)	0.357 (0.657)	0.085 (0.021)
	CD (P=1.00)	-	-	-	-	0.084 (0.587)	0.408 (0.090)	0.924 (0.687)	0.042 (0.634)	-	-	-	-	0.065 (0.614)	0.065 (0.927)	0.168 (0.085)	0.089 (0.583)
	CV (%)	-	-	-	-	2.40 (7.85)	0.630 (0.336)	0.624 (0.438)	0.681 (0.243)	-	-	-	-	0.114 (0.924)	1.95 (2.653)	0.721 (0.682)	0.864 (0.927)

*Figures in the parentheses are angular transformed values

Table 2: Effect of cow dung smoke on mortality of pulse beetle, *C. chinensis* in chickpea and pigeon pea at different time intervals

S. No.	Treatment	Per cent adult mortality of pulse beetles in pulse commodities															
		Chickpea								Pigeonpea							
		At different time intervals of smoke exposure (hour)															
		1	6	12	24	48	72	96	120	1	6	12	24	48	72	96	120
1.	Smoke	0.00	2.22	2.22	4.44	6.66 (14.95)*	21.10 (26.09)	36.66 (42.41)	46.66 (14.07)	0.00	1.11	3.33 (8.48)*	3.33 (10.25)	7.77 (16.11)	22.22 (27.95)	44.44 (34.53)	46.66 (43.08)
2.	Untreated Control (without smoke)	0.00	0.00	0.00	0.00	1.11 (4.98)	6.66 (19.08)	6.66 (22.63)	10.00 (25.49)	0.00	0.00	1.11 (3.50)	2.22 (5.31)	3.33 (8.90)	4.44 (17.86)	8.88 (21.49)	14.44 (27.64)
	SEm±	-	-	-	-	0.927 (1.236)	0.625 (0.935)	0.681 (0.351)	0.038 (0.681)	-	-	0.358 (0.928)	0.923 (0.682)	0.064 (0.137)	1.085 (0.297)	0.368 (0.068)	0.381 (0.827)
	CD (P=1.00)	-	-	-	-	1.624 (0.624)	0.062 (1.83)	0.0951 (1.349)	0.671 (0.938)	-	-	0.634 (0.397)	0.092 (0.167)	0.382 (1.627)	0.539 (0.394)	0.035 (0.521)	0.137 (0.627)
	CV (%)	-	-	-	--	1.368 (3.698)	0.837 (0.634)	1.267 (2.843)	0.372 (1.672)	-	-	2.517 (7.924)	1.650 (3.637)	0.729 (1.624)	0.927 (2.164)	2.034 (4.672)	1.610 (2.152)

*Figures in the parentheses are angular transformed values

Table 3: Effect of cow dung smoke on overall mean adult mortality of pulse beetle, *C. chinensis* on pulse commodities at different time intervals

S. No.	Treatment	Overall mean mortality of pulse beetles in pulse commodities at different time intervals of smoke exposure (hour)							
		1	6	12	24	48	72	96	120
1.	Smoke	0.00	1.38	2.77	3.88	8.60	24.99	39.71	48.05
2.	Untreated Control	0.00	0.00	0.27	0.55	2.22	4.99	6.94	11.38

Table 4: Effect of cow dung smoke on quality parameters of different pulses seeds at different exposure time period

S. No.	Cow dung smoke exposure period (hour)	Germination (%)				Germination Index				Root length (cm)			
		Mung	Urd	Chickpea	Pigeonpea	Mung	Urd	Chickpea	Pigeonpea	Mung	Urd	Chickpea	Pigeonpea
1.	1	88.33	88.33	86.66	86.66	7.57	7.57	7.42	7.42	16.96	15.54	13.15	11.30
2.	6	88.33	86.66	85.00	90.00	7.57	7.42	7.28	7.71	15.54	14.62	12.65	11.65
3.	12	88.33	85.00	86.66	88.33	7.57	7.28	7.42	7.57	14.65	14.85	12.38	10.95
4.	24	86.66	86.66	85.00	85.00	7.42	7.42	7.28	7.28	15.84	15.64	12.57	11.00
5.	48	88.33	85.00	86.66	90.00	7.57	7.28	7.42	7.71	16.35	15.32	13.69	10.95
6.	72	88.33	86.66	85.00	91.66	7.57	7.42	7.28	7.85	15.46	15.76	13.62	10.85
7.	96	86.66	86.66	86.66	91.66	7.42	7.42	7.42	7.85	15.35	14.64	12.58	11.68
8.	120	88.33	88.33	86.66	88.33	7.57	7.57	7.42	7.57	15.64	14.60	12.64	11.35
9.	Untreated Control (Without smoke)	88.33	88.33	85.00	90.00	7.57	7.57	7.28	7.71	15.68	14.95	13.38	11.20

Table 5: Effect of cow dung smoke on quality parameters of different pulses seeds at different exposure time period

S. No.	Cow dung smoke exposure period (hour)	Shoot length (cm)				Vigour index				Significance of viability			
		Mung	Urd	Chickpea	Pigeonpea	Mung	Urd	Chickpea	Pigeonpea	Mung	Urd	Chickpea	Pigeonpea
1.	1	17.65	12.50	11.34	12.5	3057.10	2476.77	2122.30	2062.50	1.00	1.00	1.01	0.96
2.	6	15.94	12.65	10.62	13.15	2780.62	2363.21	1977.95	2234.70	1.00	0.98	1.00	1.00
3.	12	15.94	12.35	11.55	12.47	2702.01	2312.00	2073.77	2068.68	1.00	0.96	1.01	0.98
4.	24	15.37	11.35	12.00	12.55	2704.65	2338.95	2088.45	2001.75	0.98	0.98	1.00	0.94
5.	48	15.64	12.84	11.62	11.64	2825.67	2392.60	2193.36	2033.1	1.00	0.96	1.01	1.00
6.	72	16.84	12.64	10.90	13.85	2853.05	2461.14	2084.20	2264.00	1.00	0.98	1.00	1.01
7.	96	15.34	12.54	11.64	12.54	2659.59	2355.41	2098.90	2220.00	0.98	0.98	1.01	1.01
8.	120	15.67	12.84	12.15	11.68	2765.61	2423.77	2148.30	2034.23	1.00	1.00	1.01	0.98
9.	Untreated Control (Without smoke)	16.92	12.65	11.80	13.64	2879.55	2437.90	2140.30	2235.60	1.00	1.00	1.00	1.00

Table 6: The overall effect of cow dung smoke on quality parameters of pulses commodities at different exposure time period

S. No.	Cow dung exposure time (hour)	Germination (%)	Germination Index	Root length (cm)	Shoot length	Vigour index	Significance of viability
1.	1	87.49	7.49	14.23	13.49	2429.66	0.99
2.	6	87.49	7.49	13.61	13.09	2339.12	0.99
3.	12	87.08	7.46	13.20	13.07	2289.11	0.98
4.	24	85.83	7.35	13.76	12.81	2283.45	0.97
5.	48	87.49	7.49	14.07	12.93	2361.18	0.99
6.	72	87.91	7.53	13.92	13.55	2415.59	0.99
7.	96	87.91	7.52	13.56	13.01	2333.47	0.99
8.	120	87.91	7.53	13.55	13.08	2342.97	0.99
9.	Untreated Control (Without smoke)	87.91	7.53	13.80	13.75	2423.33	1.00

Conclusion

Thus, based on the above findings, it can easily be concluded that the use of cow dung smoke is quite effective to increase mortality of pulse beetle in stored pulses without affecting the quality of stored pulse commodities. This is an eco-friendly, easily available, cost effective emerging traditional approach which that can easily be incorporated in the management of storage insect pests on different stored commodities under storage conditions.

References

1. Abdul-Baki A, Anderson JD. Vigour determination in soybean Seed by multiple criteria. Crop Science 1973;13:630-633.
2. Ahlawat IPS, Sharma Purushottam, Singh Ummed. Production, demand and import of pulses in India. Indian Journal of Agronomy 2016;61(4)S33-S41.
3. Ahmed KS, Itino T, Ichikawa T. Duration of developmental stages of *Callosobruchus chinensis* (Coleoptera: Bruchidae) on azuki bean and the effects of neem and sesame oils at different stages of their development. Pakistan Journal of Biological Sciences. 2003;6:932-335.
4. Anonymous. International rules for seed testing. Seed Science and Technology 1985;13:307-320.
5. Benhalima H, Chaudhry MQ, Mills KA, Price NR. Phosphine resistance in stored-product insects collected from various grain storage facilities in Morocco. Journal of Stored Products Research 2004;40(3):241-249.
6. Campo J, Masia A, Blasco C, Pico Y. Occurrence and removal efficiency of pesticides in sewage treatment plants of four Mediterranean River Basins. Journal of Hazardous Material 2013;263(Part 1):146-157.
7. Deeba F, Sarwar M, Khuhro RD. Varietal susceptibility of mung bean genotypes to pulse beetle, *Callosobruchus analis* (Fabricius) (Coleoptera: Bruchidae). Pakistan Journal of Zoology 2006;38:265-268.
8. EPA. Parameters of water quality: interpretation and standards. Environmental protection agency, Wexford 2001.
9. Faruk K, Varol I, Bayram M. The effect of carbon dioxide at high pressure under different developmental stages of *Callosobruchus maculates* (F.) hosting on chickpea. African Journal of Biotechnology. 2011;10(11):2053-2057.
10. Fishwick FB. Pesticide residue in grain arising from postharvest treatments. Applied Biology 1988;17:37-46.
11. Iqbal M, Asif S, Ilyas N, Raja NI, Hussain M, Shabir S, *et al*. Effect of plant derived smoke on germination and post germination expression of wheat (*Triticum aestivum* L.). American Journal of Plant Sciences 2016;7:806-813.
12. ISTA. International Rules for Seed Testing: edition, ISTA, Bassersdorf, Switzerland 2010.
13. Jadhav DR, Mallikarjuna N, Rao GVR. *Callosbruchus maculatus* resistance in some wild relatives and inter specific derivatives of Pigeonpea. Indian Journal of Plant Protection 2012;40:40-44.
14. Light ME, Burger BV, Staerk D, Kohout L and Vanstaden J. Butenolides from plant-derived smoke: natural plant-growth regulators with antagonistic actions on seed germination. Journal of Natural Products 2010;73:267-269.
15. Mann AK, Srivastava M. Effect of smoke treatment of plant *Aervato mentosa* on the mortality of pest *Rhizopertha dominica* (Fab.) (Coleoptera: Bostrichiadae.) Journal of Applied Research 2013;3(7):2249-555.
16. Michaelraj S, Sharma RK. Fumigant toxicity of neem formulations against *Sitophilus oryzae* and *Rhyzopertha dominica*. Journal of Agricultural Technology 2006;2(1):1-16.
17. Mishra SN, Jena BC, Guru BC. Biology of Pulse Beetle *Callosobruchus chinensis* in Storage Condition in Green Gram. International Journal of Science and Research (IJSR) ISSN (Online). 2015;4:1321-1323.
18. Novaro S, Amos TG, Williams P. The effect of oxygen and carbon dioxide gradients on the vertical dispersion of grain insects in wheat. Journal of Stored Products Research 1981;17:101-107.
19. Padmasri A, Anil Kumar B, Auna Kumari J, Srinivas C. Management of pulse beetle, *Callosobruchus chinensis* L. in red gram by modified atmosphere. Bulletin of Environment Pharmacology and Life Sciences. 2017;6(1):414-417
20. Prasantha Rohitha B, Reichmuth C, Buttner C. Effect of temperature and relative humidity on diatomaceous earth treated *Callosobruchus maculates* (F.) and *Acanthoselides obtectus* (Coleoptera: Bruchidae). 2003; p. 314–318. In: Proc. 8th Int. Work. Conf. Stored-Prod. Protect. York, England. Wallingford, Oxon, 22–26 July, CAB International 2002, 1075.
21. Rathi SS, Shah NG, Zambre SS, Kalbande VH, Venkatesh KV. Respiration, sorption and germination of seeds in controlled atmosphere. Seed Science and Technology 2000;28:341-348.
22. Riudavates J, Catane C, Pons MJ, Gabarra R. Response of eleven stored product pest species to modified atmospheres with high carbon dioxide concentrations. 9th International Working Conference on Stored Products Protection 2006;578-585.
23. Romero NJ, Johnson CD. Checklist of the Bruchidae (Coleoptera) of Mexico. The Coleopterists Bulletin. 2004;58:613-635.

24. Sarwar M. Assessment of resistance to the attack of bean beetle *Callosobruchus maculates* (Fabricius) in chickpea genotypes on the basis of various parameters during storage. Journal Science and Technology 2012;34:287-291.
25. Sayaboc PD, Dixit OP, Harshan V. Resistance of the major coleopterous pests of stored grain to malathion and primiphosmethyle. Philippine entomologist 1998;8:653-660.
26. Shazali MEH, Imamura T, Miyanishita A. Mortality of eggs of the Cowpea bruchid, *C. macculatous* (F.) (Coleoptera: Bruchideae) in carbon dioxide under high pressure. Appleid Enomology and Zoology 2004;39(1):49-53.
27. Singh RP, Srivastava BG. Alcohol extracts of neem (*Aadirachta indica*) seed oil as oviposition deterrent for *Dacus cucurbitae*. Indian Journal of Entomology. 1983;45:497-498.
28. Sinha SN, Singh SP, Srivastava C. Effect of smoke on *Rhyzopertha dominica* and *Callosobruchus maculatus* mortality and its susceptibility to phosphine. Executive Printing Services, Clovis, CA, U.S.A 2001, 431-437.
29. Sparg SG, Kulkarni MG, Van Staden J. Aerosol-smoke and smoke-water stimulation of seedling vigor of a commercial maize cultivar. Crop Science 2005;46:1336-1340.
30. Srivastava C, Sinha SND, Srinivasa Reddy. Toxicity of cow dung cake smoke to storage insects. Indian Journal of Agricultural Sciences 2006;76(4):238-241.
31. White NDG, Jayas DS. Control of insects and mites with carbon dioxide in wheat stored at cool temperatures in non airtight bins. Journal of Economic Entomology. 1991;84:1933-1942.
32. White NDG, Jayas DS, Sinha RN. Carbon dioxide as a control agent for the rusty grain beetle (Coleopteran: Cucujidae) in stored wheat. Journal of Economic Entomology 1990;83:277-288.
33. Yadav U, Tiwari R. Effect of smoke on insect mortality and quality parameters of stored wheat at Pantnagar, Uttarakhand. Journal of Entomology and Zoology Studies 2018;6:1661-1666.