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Management of pulse beetle, *Callosobruchus chinensis* L. in redgram by modified atmosphere

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ABSTRACT
The present study was aimed to study the effect of modified atmosphere with elevated levels of CO_2 on pulse beetle C. chinensis in stored redgram. Seeds were artificially infested with C. chinensis and exposed to CO_2 (30%, 40% and 50 %) and packed in air tight containers. Concentrations of 40% and 50% CO_2 checked seed infestation and also maintained seed quality without any detrimental effect on germination and seedling vigor upto nine months of storage.
Key words: Management, C. chinensis, Elevated CO_2, Redgram

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INTRODUCTION

Pulses constitute the major source of protein in the diet of developing countries. They contain 20-30% of the protein which is almost three times higher than that found in cereals. Among the pulses, pigeonpea is an important pulse crop of rainfed agriculture in the semi arid tropics. It is cultivated either as a sole crop or intercropped with cereals or other legumes. The crop, also called as redgram/tur/arhar, is widely cultivated in India. Qualitative and quantitative losses occur in pigeonpea seeds during storage due to various pests. Among the stored pests, pulse beetle (cowpea weevil) *Callosobruchus chinensis* L. (Bruchidae: Coleoptera) is the most destructive species of stored legume seeds in India as well as in other countries. It causes 33% infestation to legume seeds. Larval feeding on the cotyledons causes significant losses in seed weight and viability. Gujar and Yadav (1978) reported 55- 60% losses in seed weight and 45.5 to
66.3% losses in protein content due to bruchid infestation in storage and the infested seeds become unfit for human consumption.

The U.S. Food Quality Protection Act of 1996 focused on evaluating all registered pesticides, with particular attention to worker and consumer exposures to chemical residues. Thus, reduction or elimination of residues in grain and food was targeted by research for nonchemical alternatives (Heaps, 2006). In addition to regulatory pressures for low risk control of stored-product insects, consumers and governments around the world set standards for organic food, which should be derived from raw products that are free of human-made chemicals, among other requirements (Anonymous, 2000).

Cancellation of registration of almost all fumigants including methyl bromide and aluminium phosphide in many developed countries because of their possible carcinogenic effects on human beings has resulted in increased reliance on alternative eco-friendly pest management strategies such as modified atmosphere storage, which has relatively low mammalian toxicity and no harmful residues remain after the treatment of the commodity with CO_2. Although research has been carried out on modified atmosphere with CO_2 on

various storage pests including beetle pests and moths (Novaro *et al.,* 1981, White and Jayas, 1991 and Riudavates *et al*., 2006), the information regarding its role in controlling *C. chinensis* in red gram is very meagre. Hence, the present study was undertaken to evaluate the efficacy of various elevated levels of CO_2 in controlling pulse beetle in stored red gram at different storage intervals and the effect of modified atmosphere on storability and seed quality attributes.

MATERIAL AND METHODS:

The present study was carried out at Seed Entomology Lab, Seed Research and Technology Centre, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad, Telangana, India during 2016-2017.

Effect of modified atmosphere (MA) with elevated CO_2 on *C. chinensis* in redgram: Modified atmosphere studies with CO_2 against *C. chinensis* were carried out in specially fabricated airtight containers. Five hundred grams of disinfested redgram seeds were filled in airtight containers and ten pairs of *C. chinensis* adults were released into the containers twenty five days prior to treatment with CO_2 to ensure uniform level of infestation. After twenty five days, the weight of the red gram seeds was taken. Carbon dioxide from the cylinder was introduced into the airtight container through the 3 mm inlet tube at the bottom of the container, keeping the outlet at the top of the container open to flush out air from the container. After injecting the gas, the inlet and outlet tubes were closed at one stroke using rubber corks to prevent escape of CO_2 from the container. CO_2 was released at 3 different concentrations viz., 30%, 40% and 50% with three replications of each treatment, then plugged with rubber corks and sealed with Teflon sheet and were made airtight. Then concentration of CO_2 was checked by using CO_2 / O_2 analyzer (PBI Dansensor, PBI 200616, Denmark).Untreated control was maintained in plastic containers under ambient conditions. Modified atmosphere storage is compared with normal method of storage i.e., gunny bag storage.

Effect of modified atmosphere (MA) with elevated CO_2 on viability and vigor of seed: The airtight containers containing the disinfested seed exposed to different concentrations of CO_2 were observed at three months interval up to twelve months of storage. After completion of each exposure period, the seal of container was opened and observations on insect damage (%), moisture content (%), germination (%) and seedling vigor index were recorded. The number of damaged seeds in each replication was counted after taking a random sample of 100 g seeds and converted to per cent insect infestation. The seed moisture content of the treatments was determined by "Dicky John" moisture meter. Seed germination was measured using standard paper towel method as per the ISTA rules (1999). Germinated seeds were counted on 9th day and ten germinated seedlings were selected from each replication of the treatment for calculating the seedling vigor index. The shoot and root length of each of the ten seedlings were measured in centimeters and total length of the seedling was calculated.

Seedling vigour index (SVI-I) = Germination (%) x Total seedling length (cm)

Statistical analysis: The data was analyzed by adopting completely randomized design according to Panse and Sukhatme (1978).

RESULTS AND DISCUSSION:

Effect of modified atmosphere (MA) with elevated CO2 on *C. chinensis* in Redgram:

Effect of modified atmosphere (MA) with elevated CO_2 on per cent seed damage:

From the data (Table1), it is evident that upto 3 months of storage, all the CO_2 treatments (30%, 40% and 50%) were able to restrict insect damage below the permissible limit i.e., 1 %. At 6 months of storage, lowest per cent seed damage was recorded in 50 % CO_2 (0.12%). At nine months of storage, lowest per cent damage was observed in 40% CO_2 (0.17%), however it is at par with 50% CO_2 (0.22%). At Twelve months of storage, lowest per cent damage was observed in 50% CO_2 (2.5%), however it is at par with 40% CO_2 (3.2%) but both the treatments were unable to restrict insect damage below permissible limit.

Effect of modified atmosphere (MA) with elevated CO_2 on Germination:

The study revealed that the germination percentage of redgram seeds exposed to different concentrations of CO_2 had no significant variation among the concentrations during 3 and 9 months of exposure (Table 1). The difference in germination percentage was observed at 6 and 12 months of exposure, but all the treatments were able to maintain germination percentage as per IMSCS (>75%) upto 12 months of storage.

Moisture content (%): There was significant variation among the treatments upto six months of exposure (Table 1). No significant difference among the treatments was observed at 9th and 12th months

after exposure. At 12th month after treatment, moisture content varied from 10.1 % (gunny bag storage) to 11.1% (airtight container without CO_2 release).

Seedling vigour index: Studies conducted with redgram seeds exposed to different concentrations of CO_2 did not show significant variation in vigour index from six months to twelve months of storage (Table 1).

Our results indicated that redgram seeds exposed to 30% CO_2 protected upto three months, while1.10%, 2.62% and 4.0% seed damage was recorded at 6th, 9th and 12th month after treatment respectively. Insect damage noticed was below permissible limit with 40% and 50% CO_2 concentrations upto nine months. The study suggests that 40% and 50% CO_2 are more toxic to *C. chinensis* and can be recommended for long term storage of Redgram seed. Bera *et al.* (2004) reported that complete control of seed damage by lesser grain borer, *R. dominica* and rice moth, *Corcyra cephalonica* was achieved when the seed was subjected to 20% CO_2 concentrations within two months of storage period. Bera *et al.* (2007) and White and Jayas (1990) also reported that complete control of rice weevil and lesser grain borer in rice was obtained with 20, 40, 60 and 80% CO_2 concentrations even after 12 months of storage. Shehata *et al.* (2009) observed lowest infestation by *C. maculatus* when cowpea seeds were treated with 80% CO_2. Jayas and Jeyamkondan (2002) and Sharaf (2000) concluded that modified atmosphere do not cause any detrimental effect on functional characteristics of grains and help in maintaining seed germination and viability. Decrease in germination could be due to the infestation of redgram seed by *C. chinensis* and ageing of seed. White and Jayas (1993) obtained complete control of *Tribolium castaneum* and *C. ferrugenius* in stored wheat and barley seeds when exposed to 34% CO_2 without significant effect on seed germination. Rathi *et al*., 2000 reported that CO_2 exposed red gram seeds had less insect infestation, less mould attack and retained high germination per cent when compared to untreated seeds. Bera *et al.* (2004) opined that storage in CO_2 rich atmosphere irrespective of concentrations and exposure period showed no adverse effect on germinability of wheat seed. Shehata *et al.* (2009) stated that the germination per cent of cowpea seeds stored upto six months under controlled atmosphere was higher than the untreated seeds. Similar findings were reported by Bera *et al.* (2004) that the germinability of wheat seed was not adversely affected by CO_2 rich atmosphere when stored for six months with 12% moisture content. Bera *et al*. (2008) reported that without much reduction in seed viability, paddy seed can be stored safely with 11% moisture content at least upto 12 months under modified atmosphere upto 80% CO_2

Finally it is evident that the modified atmosphere with higher CO_2 content (40% and 50%) was found to be ideal and eco-friendly approach for the management of *C. chinensis* in stored pulses instead of conventional harmful fumigants and poisonous insecticidal sprays. Hence, these findings are important for the recommendation of safe, residue free and long-term storage of redgram without any qualitative and quantitative losses.

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Table: 1 Effect of carbon dioxide (CO_2) treatment on the control of storage insect pests and the seed quality attributes under ambient conditions (redgram seed 2016-17)

	Storage duration															
Parameter	3months				6months				9 months				12 months			
CO_2 Conc	G%	SVI	M %	ID %	G%	SVI	M%	ID %	G%	SVI	M%	ID%	G%	SVI	M%	ID%
0% CO_2	95.0	1783	12.10	2.40	87.3	1884	10.27	1.42	91	1975	10.9	9.12	92.7	1933	11.1	14.5
30% CO_2	95.3	1742	11.00	0.30	96.3	2080	9.20	1.10	93	1790	11.2	2.62	94.3	1903	10.9	4.0
40% CO_2	97.0	1824	10.40	0.47	95.0	2121	9.17	0.87	92	1948	11.0	0.17	83.7	1785	10.4	3.2
50% CO_2	96.7	1960	9.63	0.20	97.3	2135	9.33	0.12	97	2114	11.1	0.22	93.3	1819	10.6	2.5
Gunny bag	95.3	1790	14.33	3.10	95.0	2214	10.07	3.28	92	1881	11.2	4.67	88.3	1900	10.1	5.4
CD at 5%	NS	65.145	0.96	0.17	2.5	N.S.	0.31	0.25	NS	NS	NS	0.48	4.63	N.S.	N.S.	1.14

G=Germination; SVI=Seedling Vigour Index; M=Moisture content; ID= Insect Damage in seed

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