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Suitability of Sand Layer Technology for the Management of *Callosobruchus chinensis* L. on Stored Chickpea

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ABSTRACT: Pulses are a crucial crop for human nutrition since the seeds have increased protein content. India is the world's largest producer of pulses, with the chickpea being one of the most important. The major biotic factors are pulse beetles, and *Callosobruchus chinensis* L. is one of them that causes severe infestations and losses in stored chickpea. For small and subsistence farmers, the available modern management alternatives, such as the use of pesticides and irradiation, were neither cost-effective nor safe. Thus, the current study was carried out to assess sand layer technology as a reliable and cost-effective option for the management of *C. chinensis*. The experiment involved covering chickpea grains with thin layers of sand to determine the ideal sand thickness for safe storage of chickpea for six months. It found that treatments with no sand layer and then treatments with 0.5 cm sand layer recorded the highest levels of infestation parameters. The most effective treatment was to cover chickpea grains with 1.5 cm sand layer, which significantly reduced the infestation parameters on pre-infested chickpea grains. This was attributed to the absence of open area for beetles to breed on the grain surface as well as the absence of inter-grain space, which was covered in fine sand which may interrupted the female beetles to lay eggs. Therefore, this technique would serve as an economical and eco-friendly method for storing chickpeas on a small scale or household levels.

Keywords: Chickpea, Sand layer, Pulse beetle, *C. chinensis*, Management.

INTRODUCTION

Pulses crops of the Fabaceae family are an important crop for human nutrition because they are the cheapest source of protein (20-25%) and are extremely beneficial with their variety of uses such as their adaptability in diverse cropping systems, soil fertility improvement with N fixation, and so on (Patterson *et al.,* 2009). When compared to other countries, India produces the most pulses (27.69 mt from an area of 35 mha, with a productivity of 649 kg/ha). Lentil, chickpea, pigeonpea, mungbean, urdbean, and dry pea are the main pulses grown in India; chickpea accounts for 48% of total production, followed by pigeonpea (17%), blackgram (10%), greengram (7%), and other pulses (18%) (Anonymous, 2021). During 2021-22, the country produced a record amount of pulses (27.69 million tonnes) from an area of 35 million ha with a productivity of 649 kg/ha, reaching self-sufficiency for domestic pulses demand (Anonymous, 2022). Chickpea is an important pulse crop in India and around the world, and it is known for its high seed protein content. A variety of biotic and abiotic factors contribute considerably to the reduction of chickpea production, with bruchids (*Callosobruchus* spp., Chrysomelidae: Coleoptera) being the most significant biotic factor causing serious losses of chickpea grains in the field and storage. *Callosobruchus chinensis* L. is the most severe of numerous bruchid species, producing post-harvest losses of chickpea that can exceed field level losses caused by other insect-pests. The losses range from 4 to 100% depending upon the timely interventions (Southgate, 1978; Talekar, 1988; Mishra *et al*., 2017).

Consistent milestones in Indian pulses production have resulted in their large-scale storages across the country. No doubt, pulses are prone to insects when stored improperly due to higher nutrition properties of seeds. The bean beetle (*C. chinensis*) is an important bruchid species that auses initial infestation in the field and significant economic damage during storage (Srivastava and Pant 1989; Ramzan *et al*., 1990). As a result, these insects may ruin the quality, quantity, and nutrition of stored pulses, posing a serious danger to food security. Current bruchid management approaches rely on chemicals to get faster results while ignoring the health and environmental repercussions of indiscriminate use. Following the prohibition of methyl bromide, pulse storage is entirely reliant on a few prophylactic (Malathion, Deltamethrin) and fumigant (Aluminium Phosphide). Though these chemicals are excellent options, they are only practical for medium to large-scale pulse storage. However, small and subsistence farmers who store small quantities of grains in bins or containers, as well as household/kitchen level storages in containers, face feasibility, safety, and applicability issues when using these chemicals. There are numerous non-chemical solutions to these challenges, one of which is the formation of a sand layer atop stored grains.

Sand layer technology was developed by Regional Centre, ICAR-AICRP on Post-Harvest Technology, UAS, Bengaluru for successful management of insect pests infesting different stored grains (Subramanya *et al.,* 2006). This technology is suitable for small scale grain storage (kilograms to couple of quintals) at domestic/farm level where grains are stored in open containers or bins. It includes creation of a thin layer of fine sand above the grains stored in containers or bins which blocks the surface space being utilized by the beetles for mating activity. This technique is more successful in grains with less inter-grain space as larger inter-grain space may provide required space for mating activity. Assuming different inter-grain space in different stored pulses that may challenge sand layer technology; it is interesting to validate this technology in *Desi* chickpea. Considering above points, the present was devised to optimize the thickness of sand layer for safe storage of chickpea for over six months by protecting them against *C. chinensis.*

MATERIAL AND METHODS

The present study was carried out under laboratory conditions at Department of Entomology, Chandra Shekhar Azad University of Agriculture & Technology; and ICAR-Indian Institute of Pulses Research, Kanpur, during 2020-21 and 2021-22. The chickpea variety 'Udai' (KPG-59) was selected for the experiment since this variety has a wide popularity among the farmers of central region of Uttar Pradesh. The pure stock culture of pulse beetle species *C. chinensis* was obtained from Division of Crop Protection, ICAR-Indian Institute of Pulse Research, Kanpur. The culture was multiplied on fresh and infestation free chickpea grains following the available protocol (Strong *et al.* 1968) under controlled laboratory conditions (27±2ºC and 65±5 % RH, 10:14 light: dark) (Aidbhavi *et al.,* 2021).

The experiments were conducted in Completely Randomized Design using *Desi* chickpea covered with 4 different thickness of sand layers *viz*., 0, 0.5, 1 and 1.5 cm, separately with five replications per treatment combination. Each sample contains 0.5 kg of chickpea grains was stored in plastic containers separately. For each container 25 pair of fresh beetles were released. Fine sand from river bed was taken, sundried to remove moisture, cleaned and then used to create layers of different thickness on chickpea grains surface. After six months, the observations on percent grain - weight loss, infestation, damage and adult density were recorded from representative sample from all the treated samples.

A. Grain weight loss (%)

The grain weight was recorded twice during pre-incubation and post adult emergence. The grains of each sample were separated into damaged (grains with characteristic damage holes) and undamaged ones and weighed separately using electronic precision weighing balance (Model: ACZET 202). Per cent weight loss was calculated using the formula given by Adams (1976) as follows:

$$\text{Weight loss in percentage} = \frac{(UNd) - (DNu)}{U\,(Nd + Nu)}$$

Where,

U- weight of undamaged grains, Nu- number of undamaged grains, Nd- number of damaged grains, D- weight of damaged grains.

B. Grain infestation (%)

The chickpea seeds with eggs were counted using hand lens. The total number of seed with eggs were divided by the total number of seeds present in each sample, and the per cent grain infestation was estimated with the following formula:

Per cent infestation of grains =

$$\frac{\text{Total no. of seeds with eggs}}{\text{Total no. seeds}} \times 100$$

C. Grain damage (%)

The grains from each sample were separated into damaged (grains with characteristic holes) and undamaged ones. Using this data, the per cent grain damage was calculated using the following formula given by Boxall (1986):

Per cent grain damage = [Nd / (Nd + Nu)] ×100

Where, Nu-number of undamaged grains, and Nd-number of insect damaged grains.

D. Adult emergence (%)

The number of adults present were counted at the end of the experiment duration of 6 months and recorded from each treatment combinations.

RESULT AND DISCUSSION

A. Grain infestation (%)

During 2020-21, the observations on grain infestation by *C. chinensis* on chickpea grains covered with different layers of sand were differed significantly between treatments (Table 1 and Fig. 1). After six months of storage, the stored chickpea grains covered with 1.5 cm sand layer recorded significantly lower infestation (68.80±2.187 %) followed by 1.0 cm (88.51±0.954 %), 0.5 cm (98.49±0.537 %). The highest per cent weight loss was seen in chickpea grains with no sand layer covered (control 98.55±0.787 %) which was on par with sand layer of 0.5 cm and differed significantly from all other treatments. Similarly, during 2021-22, the least per cent grain infestation was found in chickpeas covered with sand layer treatment of 1.5 cm (67.58±1.554), followed by 1.0 cm (88.82±0.73) and 0.5 cm (98.84±0.504). The highest per cent weight loss was seen in control *i.e.* no sand layer (98.20±0.938) which was on par with sand layer of 0.5 cm and differed significantly from all other treatments (Table 2 & Fig. 2).

B. Grain damage (%)

During 2020-21, the least per cent grain damage after six months of storage was found in treatment with sand layer of 1.5 cm (36.51±1.652) followed by 1.0 cm (65.88±1.357) and 0.5 cm (98.85±0.500). The highest per cent weight loss was seen in control *i.e.* no sand layer (99.43±0.323) which was on par with sand layer of 0.5 cm and differed significantly from all other treatments. (Table 1 and Fig. 1). Similar results were obtained in validation experiment (2021-22) wherein the least per cent grain damage was found in chickpeas covered with sand layer of 1.5 cm (36.31±0.912), followed by 1.0 cm (67.02±1.729), 0.5 cm (98.14±0.909) and control (98.48±0.724), which was on par with sand layer of 0.5 cm and differed significantly from all other treatments (Table 2 and Fig. 2).

C. Adult emergence (%)

The observations recorded during 2020-21 revealed that the adult emergence was varied significantly between chickpeas covered with different sand layer treatments (Table 1 and Fig. 1). The least per cent weight loss after six months was found in chickpeas covered with sand layer of 1.5 cm (234.60±7.427), followed by 1.0 cm (448.40±10.689) and 0.5 cm (703.20±4.800). The highest per cent weight loss was seen in control (794.00±15.840) which differed significantly from all other treatments. During second year (2021-22), the least per cent weight loss was found in chickpeas covered with sand layer of 1.5 cm (258.00±9.127) followed by 1.0 cm (464.00±7.000) and 0.5 cm (710.20±9.205). The highest per cent weight loss was seen in control *i.e.* no sand layer (791.00±13.943) which differed significantly from all other treatments (Table 2 and Fig. 2).

D. Grain weight loss 9%)

During 2020-21, the observations revealed that the least per cent weight loss after six months of storage was found in treatment with sand layer of 1.5 cm (18.28±0.372) followed by 1.0 cm sand layer (40.90±0.438), sand layer of 0.5 cm (45.30±0.595) and the highest in control *i.e.* no sand layer (49.00±0.350) which differed significantly from all other treatments (Table 1 and Fig. 1). In the confirmation experiment (2021-22), the least per cent weight loss found in treatment with sand layer of 1.5 cm (18.41±0.409) followed by 1.0 cm (38.62±0.413) and 0.5 cm (45.53±0.336). The highest per cent weight loss was seen in control (49.81±0.848), which differed significantly from all other treatments.

In the present study conducted two years, the chickpea grains covered with 4 different thickness of sand layers *viz.*, 0, 0.5, 1 and 1.5 cm, separately to test the suitability of sand layer technology for small scale storage of grains in an open bins at farm or household level. The direct loss caused by *C. chinensis* on infested chickpea grains were measured in terms of infestation, grain damage, weight loss and adult emergence. The significant difference among the treatments were clearly depicted in the findings. It was found that the higher infestation parameters were in the treatment with no sand layer followed by 0.5 cm sand layer. The most effective treatment was 1.5 cm sand layer wherein the least infestation, grain damage, weight loss and adult emergence were recorded. This was due to the non-availability of open surface for mating by beetles and also non availability of inter grain space which was covered by fine sand that might have affected the space required by female beetle to lay eggs on the grain surface. Therefore, placing layer of dry sand at the top of the grain mass which further reduces the population buildup (Lal and Verma 2007; Gopala Swamy *et al.,* 2018).

Similar results were reported by Subramanya *et al.* (2006) reported that the sand layer is a simple, cheap and low cost non-chemical method of storing pulse grains safely for a longer period which involves an extended sun-drying of grains to remove the field infestation followed by a sand layer of 3 cm thick above the grain mass, in a plastic or metal bin with air-tight lid to prevent any possible cross-infestation. Sunitha *et al.* (2013) found in her study that, in six months among the different seed treatments, it was observed that sand layer of 2.5 cm thick above the seeds was found to be effective in maintaining minimum bruchid population, per cent seed damage, weight loss, seed germination and high per cent protein content at the end of storage.

Table 1: Effect of sand layer on storability of chickpea after six months during 2020-2021.

Treatment No.	Treatment details	Grain infestation (%)	Grain damage (%)	Grain weight loss (%)	Adult emergence
		Mean ± S.E.	Mean ± S.E.	Mean ± S.E.	Mean ± S.E.
T_1	Sand layer of 0 cm	98.55±0.787[c]	99.43±0.323[c]	49.00±0.350[d]	794.00±15.840[d]
T_2	Sand layer of 0.5 cm	98.49±0.537[c]	98.85±0.500[c]	45.30±0.595[c]	703.20±4.800[c]
T_3	Sand layer of 1.0 cm	88.51±0.954[b]	65.88±1.357[b]	40.90±0.438[b]	448.40±10.689[b]
T_4	Sand layer of 1.5 cm	68.80±2.187[a]	36.51±1.652[a]	18.28±0.372[a]	234.60±7.427[a]
Grand mean		88.587	75.167	38.369	545.050
SE(m)		0.642	0.555	0.225	5.264

Table 2: Effect of sand layer on storability of chickpea after six months during 2021-2022.

Treatment No.	Treatment details	Grain infestation (%)	Grain damage (%)	Grain weight loss (%)	Adult emergence
		Mean ± S.E.	Mean ± S.E.	Mean ± S.E.	Mean ± S.E.
T_1	Sand layer of 0 cm	98.20±0.938[c]	98.14±0.909[c]	49.81±0.848[d]	791.00±13.943[d]
T_2	Sand layer of 0.5 cm	98.84±0.504[c]	98.48±0.724[c]	45.53±0.336[c]	710.20±9.205[c]
T_3	Sand layer of 1.0 cm	88.82±0.731[b]	67.02±1.729[b]	38.62±0.413[b]	464.00±7.000[b]
T_4	Sand layer of 1.5 cm	67.58±1.554[a]	36.31±0.912[a]	18.41±0.409[a]	258.00±9.127[a]
Grand mean		88.362	74.987	38.093	555.800
SE(m)		0.505	0.569	0.271	5.071

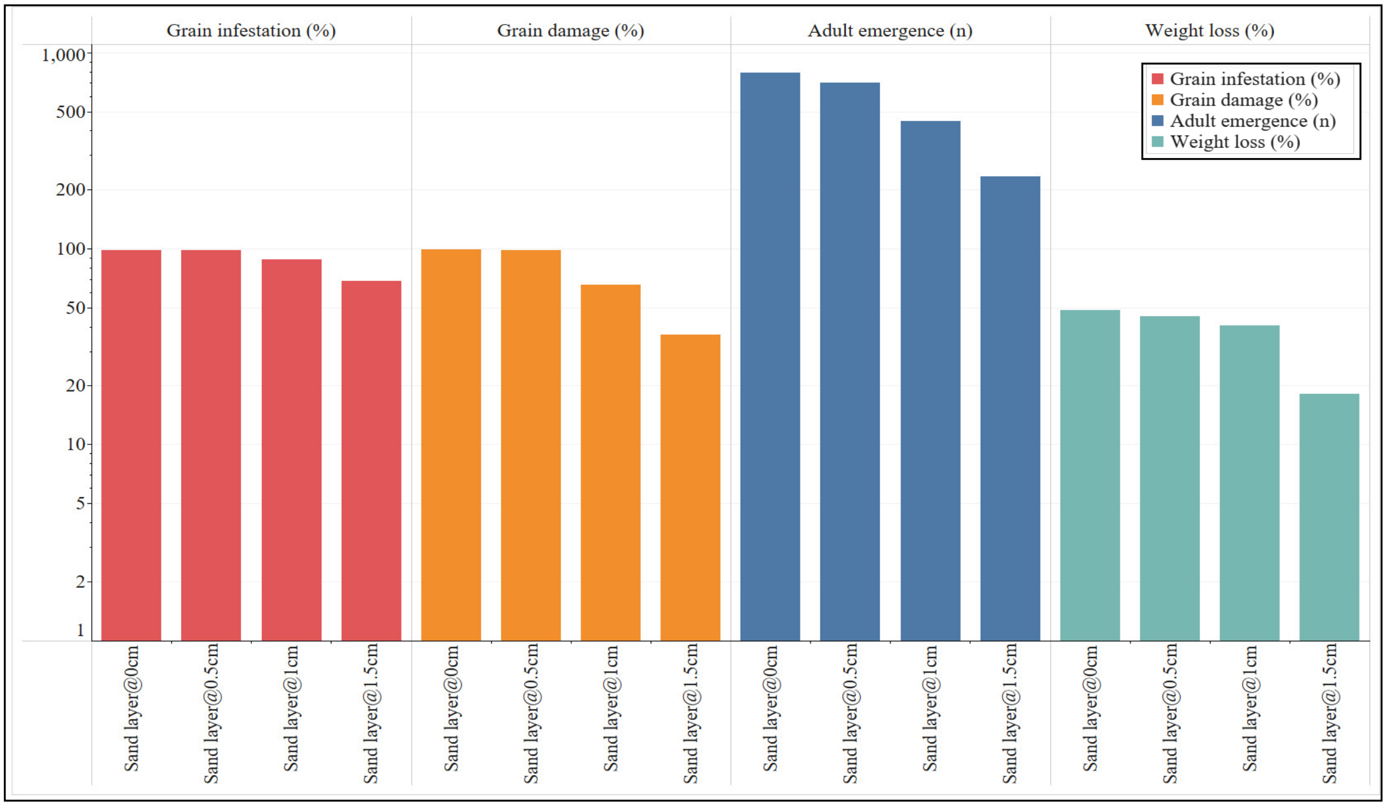

Fig. 1. Effect of sand layer on storability of chickpea after six months during 2020-2021.

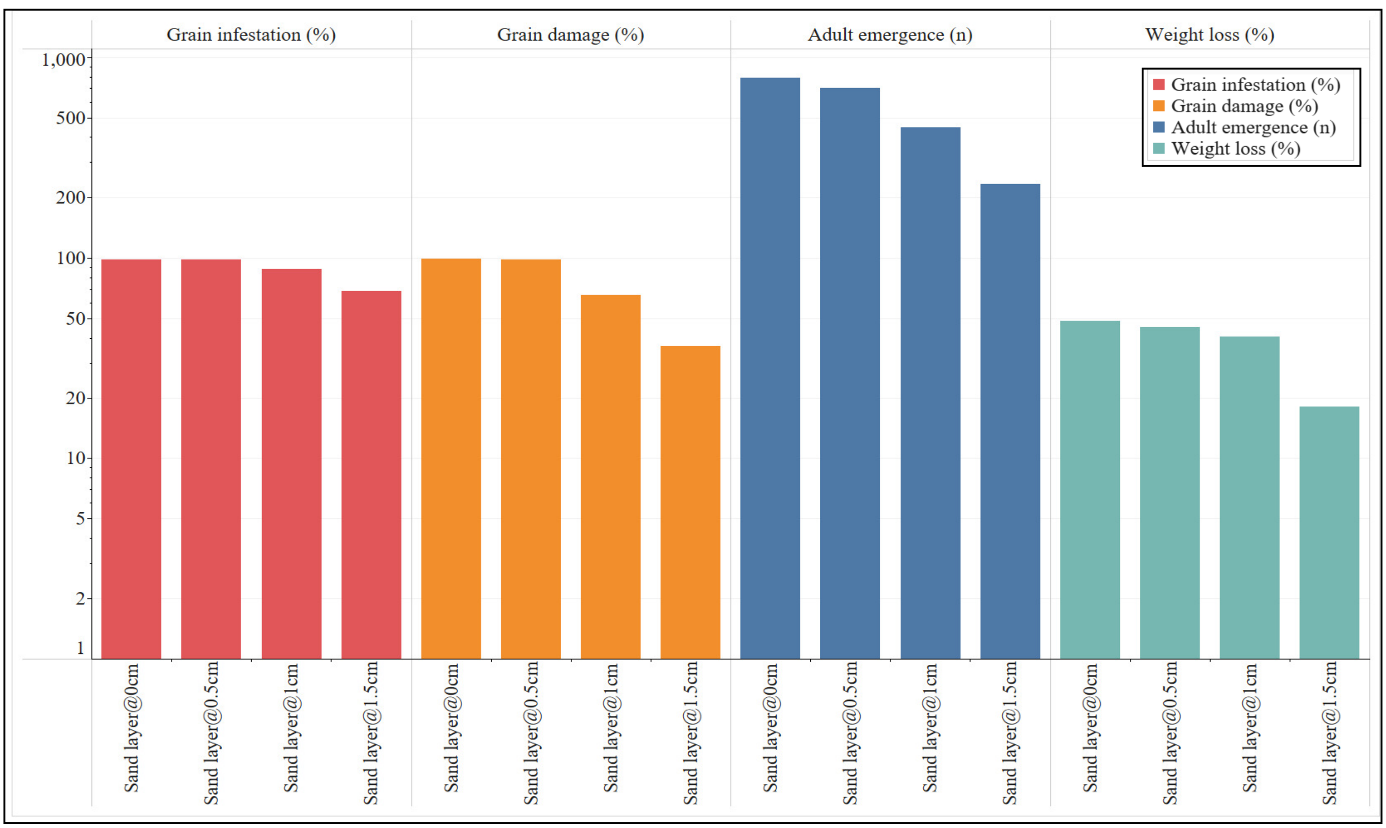

Fig. 2. Effect of sand layer on storability of chickpea after six months during 2021-2022.

Gopala Swamy *et al.* (2015) conducted an experiment to evaluate the efficacy of certain biorational approaches against the pulse beetle (*C. chinensis*) in stored blackgram. There was no adult emergence in the sand layer of 3 cm on the top of grain treatment even after 150 days of storage, as the released adults could not enter through the sand layer and lay eggs over the grain. This technique was also tested for storage of various pulses such as blackgram, greengram and pigeonpea meant for seed purpose.

Some studies on sand layer also found that the germination, viability of seeds irrespective of the variety was retained and no cross infestation upto 9 months (Gopala Swamy *et al.,* 2018). Sarada *et al.* (2018) found that the Excess Proportion Index for the sand layer treatment was -0.84 as the insects could not access the grains in blackgram. Therefore, the pulse grains treated by this method can be effectively stored for any length of time as long as the sand layer is not disturbed and grains are not exposed Subramanya and Ranganna (2018). Many reports suggested the use of 3 cm sand layer in contrast to the present study's effective thickness of 1.5 cm sand layer, which is 50 % less thickness. So sand layer technology is of farmer friendly, eco-friendly and can be used in small scale grain storage at farm level.

CONCLUSIONS

Present findings clearly suggests that creation of 1.5 cm thick sand layer on chickpea grain surface provides protection against pulse beetle for over six months. It is the effective method in case of small scale/ household level/ farm level storage and also it is an eco-friendly and economically feasible option. To conclude, the above effective treatment can be used as an alternate options to the chemical options for management of bruchids in small scale storage thereby helping famers or household level grain storages to address the issues of economic feasibility management option overcoming health and environmental concerns.

FUTURE SCOPE

For small and subsistence farmers, the available modern management alternatives, such as the use of pesticides and irradiation, were neither cost-effective nor safe. Therefore, the Present study helps farmers to store the grains at farm level in small scales or household level without use of chemicals. Even the organic pulses can be stored by this method. Studies can be further conducted by using combination of other traditional methods with sand layer and for different pulses.

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Conflict of Interest. None.

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