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Assessment of various packaging materials for pulse storage against pulse beetle (*Callasobruchus chinensis* L.)

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Abstract
The present investigation on "Effectiveness of Packaging Materials and Storage Containers against Pulse Beetle (*Callasobruchus chinensis* L.)" was carried out by conducting a laboratory experiment by using various packaging materials *viz.* jute bag, gunny bag, polythene bag and cloth bag seeds of black gram in association with silica (2%) at Department of Entomology, Rajasthan College of Agriculture, MPUAT, Udaipur during 2020-2021. Polythene bags with silica (2%) was found to be best effective treatment among various packaging materials against pulse beetle during storage having minimum oviposition (21.33); seed damage (3.33%) and weight loss (7.93%) followed by gunny bags with silica (2%) (35.66, 4.60% and 11.67%); cloth bags with silica (2%) (39.53, 6.10% and 13.19%); Polythene bags without silica (41.86, 6.66% and 15.09%); jute bags with silica (2%) (43.86, 8.53% and 15.12%); gunny bags without silica (97.73, 17.40% and 27.86%); cloth bags without silica (109.26, 22.26% and 31.54%) and jute bags without silica (143.53, 27.86% and 37.89%).

Keywords: storage pest, jute bag, gunny bag, polythene bag, cloth bag and black gram

Introduction
Agriculture is an important sector of the Indian economy, accounting for fourteen per cent of the nation's GDP, about eleven per cent of its exports, about half of the population still relies on agriculture as its principal source of income and it is a source of raw materials for a large number of industries. In India, total pulse area and production during 2019-20 has been 283.4 Lakh ha and 23.2 million tons. Rajasthan occupied second position in area and second position in pulses production. In Rajasthan total pluses production 4.49 million tonns and area 48.19 Lakh ha in 2019-20. Black gram is scientifically known as *Vigna mungo* and it is a member of the Asiatic Vigna crop group. It is an annual grown pulse crop and commonly known as *Urad* in India. India is its primary origin and is mainly cultivated in Asian countries including Pakistan, Myanmar and parts of southern Asia. About 70% of world's black gram production comes from India.

In India about 70% of farm produce is stored at farmers level using different types of storage structures made from locally available materials (Shukla and Pati, 1998) [8]. Proper packaging materials and storage containers are essential for retaining the seed quality and viability. Before or during marketing the commodity has to be stored in suitable containers/packings. The infestation intensity of different insect-pests is variable with different storage structures and practices (Meena and Bhargava, 2003) [5]. Storage conditions and containers in addition to preservation and maintenance of healthy seed play a significant role in keeping the stored commodity free from the storage pest infestation during post-harvest period.

Silica dust is considered as one of the environments eco-friendly alternative to chemical pesticide in stored pest management (Stadler *et al*. 2012) [9]. Silica is chemically stable, highly persistent and has low mammalian toxicity, mainly composed of silica dioxide (synthetic silica), natural silica (diatomaceous earth), kaolinite and silica gel which predominately consistent of atmosphere and shapeless silica. Silica dust becomes more effective against insects because it removes or adsorb the epicuticular lipid layer which results in excessive water loss through cuticle (Stadler *et al*., 2012) [9]. Among the all available natural resource silica dust has proven to be more effective against storage pests. Silica being non-toxic, chemical free and pest resistance free and for this reason it can be used against storage pest. Therefore, efficacy of different packaging materials under laboratory conditions in combination of silica (2%) was undertaken.

Materials and Methods

To study the "Effectiveness of different packaging materials against pulse beetle" the experiment was laid out in Factorial Completely Randomized Design in two factors *viz.* jute bag, gunny bag, polythene bag and cloth bag filled with 500g seeds of black gram with and without 2% silica in three replicates. Before the set-up of experiment, pulse beetle (*C. chinensis*) was mass multiplied for stock culture and for this live culture of pulse beetle (*C. chinensis*) was procured from the nucleus culture available in the Department of Entomology and transferred in a 5kg jars containing 4 kg of healthy and infestation free black gram seeds of variety 'PU-1' at room temperature. To maintain proper aeration and to raise the moisture content for the fast multiplication of pulse beetle, the jar was covered with muslin cloth with the help of rubber bands. After the multiplication reached sufficient numbers, the adults from this stock culture were utilized for further experimentation. Ten pairs of pulse beetle from the stock culture were released in each treatment and replication containing one kilogram of black gram seeds, variety PU-1. Observations were recorded at 30, 45, 60, 75and 90 days after the storage in terms of number of eggs present on 100 seeds of black gram, percent seed damage, per cent weight loss and per cent germination.

Observations

Per cent seed damage: The healthy seeds (un-infested) were sorted out and remaining infested or damaged seeds were counted. The per cent seed damage was calculated by the following formula:

$$\text{Per cent seed damage} = \frac{\text{Number of damage seed}}{\text{Total number of seeds used}} \times 100$$

Per cent weight loss: Seeds samples of each treatment were utilized after separation of damaged (holed) and undamaged seeds.

$$\text{Per cent weight loss} = \frac{(W\mu \times Nd) - (Wd \times N\mu)}{W\mu \times (Nd + N\mu)} \times 100$$

Where,
Wμ = Weight of undamaged seeds
Nμ = Number of undamaged seeds
Wd = Weight of damaged seeds
Nd = Number of damaged seeds, No. of insect damaged seeds

Per cent germination: The Per cent germination was determined by using the Between-paper method as described by Rao *et al.,* 2006. for this, moist blotter paper was kept in one half of petri-plates and on these 100 seeds from each treatment in set of three replication, were transferred and these seeds were again covered by moist blotter paper to ensure proper moisture for germination and then covered by another half of petri-plates to prevent moisture loss. The observation on germination from each sample was recorded after six days and per cent germination was worked out by following formula:

$$\text{Per cent Germination} = \frac{\text{Number of Germinated Seed}}{\text{Total Number of Tested Seed}} \times 100$$

Statistical analysis: The experimental data were tabulated and statistically analyzed as per the standard procedure for analysis of variance through the method appropriate for experiment carried out in factorial Completely Randomized Design. The comparison in the treatment mean was tested by critical difference (CD) at 5% level of significant.

Results and Discussion

The experiment was conducted by storing black gram seeds in various packaging materials *viz*. polythene bags, cloth bags, gunny bags and jute bags using factorial design with or without silica (2%) to evaluate the effect of abovementioned packaging materials in association with silica (2%) against pulse beetle. The effect was evaluated on the basis of oviposition, per cent seed damage and per cent weight loss; which confirmed the use of silica (2%) in each packaging material to be superior. Whereas, presence of silica in respective packaging materials had no significant effect on Per cent germination. The best treatment in term of minimum oviposition, per cent seed damage, per cent weight loss and per cent germination was found to be polythene bags (31.70), (4.80%), (11.32%) and (73.42%); followed by gunny bags (66.70), (10.90%), (19.76%) and (67.45%); cloth bags (74.40), (14.03%), (22.36%) and (66.07%) and jute bags (93.70), (17.53%), (26.73%) and (62.69%), respectively. [Table 1, 3, 5 and 7]

Table 1: Effect of different packaging materials and silica on oviposition by pulse beetle on black gram (2020-21)

Eggs pulse beetle (No.)						
Packaging materials	**30 Days**	**45 Days**	**60 Days**	**75 Days**	**90 Days**	**Overall mean**
Cloth bags	29.33	49.67	69.83	99.00	124.17	74.40
Polythene bags	11.33	22.66	32.17	41.17	51.16	31.70
Jute bags	40.50	59.33	81.50	117.50	169.66	93.70
Gunny bags	22.00	41.50	67.00	91.00	112.00	66.70
S. Em. ±	0.65	1.13	1.15	2.65	2.32	1.59
C.D. (P = 0.05)	1.96	3.40	3.46	7.97	6.96	4.77
Silica with or without treated factor						
Without silica	38.83	62.75	89.66	127.66	171.58	98.10
Silica	12.75	23.83	35.58	46.66	56.91	35.15
S. Em. ±	0.46	0.80	0.81	1.88	1.64	1.12
C.D. (P = 0.05)	1.39	2.40	2.44	5.63	4.92	3.36

Table 3: Effect of different packaging materials and silica on per cent seed damage by pulse beetle on black gram (2020-21)

Per cent seed damage (%)						
Packaging materials	**30 Days**	**45 Days**	**60 Days**	**75 Days**	**90 Days**	**Overall mean**
Cloth bags	6.83	11.16	13.66	17.50	21.00	14.03
Polythene bags	1.83	3.83	5.00	6.00	7.33	4.80
Jute bags	9.66	14.16	17.50	21.33	25.00	17.53
Gunny bags	5.33	7.33	10.50	14.00	17.33	10.90
S. Em. ±	0.32	0.51	0.39	0.58	0.66	0.50
C.D. (P = 0.05)	0.96	1.54	1.17	1.74	1.99	1.49
Silica with or without treated factor						
without silica	9.75	14.50	17.99	22.83	27.66	18.55
Silica	2.00	3.75	5.16	6.582	7.66	5.03
S. Em. ±	0.22	0.36	0.27	0.41	0.47	0.35
C.D. (P = 0.05)	0.68	1.08	0.82	1.23	1.41	1.05

Table 5: Effect of different packaging materials and silica on per cent weight loss by pulse beetle on black gram (2020-21)

Per cent weight loss (%)						
Packaging materials	**30 Days**	**45 Days**	**60 Days**	**75 Days**	**90 Days**	**Overall mean**
Cloth bags	11.60	16.92	22.43	28.47	32.41	22.36
Polythene bags	4.68	8.12	11.64	14.65	17.44	11.32
Jute bags	14.73	21.88	28.16	32.88	36.01	26.73
Gunny bags	9.90	15.31	19.69	25.84	28.08	19.76
S. Em. ±	0.08	0.78	0.57	0.73	0.57	0.54
C.D. (P = 0.05)	0.25	2.33	1.72	2.19	1.71	1.64
Silica with or without treated factor						
Without silica	15.93	21.51	28.34	34.99	39.20	27.99
Silica	4.52	9.60	12.61	15.93	17.77	12.09
SEm±	0.05	0.55	0.40	0.51	0.40	0.38
C.D. (P = 0.05)	0.17	1.65	1.22	1.54	1.21	1.16

Table 7: Effect of different packaging materials and silica on per cent germination on black gram (2020-21)

Per cent germination (%)						
Packaging materials	**30 Days**	**45 Days**	**60 Days**	**75 Days**	**90 Days**	**Overall mean**
Cloth bags	73.83	70.67	65.23	61.35	57.24	66.07
Polythene bags	79.83	77.83	73.73	69.68	66.02	73.42
Jute bags	71.00	68.33	63.23	57.35	53.52	62.69
Gunny bags	75.33	72.00	68.17	63.85	58.52	67.45
S. Em. ±	0.692	1.06	0.83	0.79	0.94	0.70
C.D. (P = 0.05)	2.075	3.18	2.49	2.37	2.83	2.11
Silica with or without treated factor						
Without silica	74.42	71.25	66.75	62.53	58.04	66.60
Silica	75.58	73.17	68.13	63.58	59.35	67.96
S. Em. ±	0.48	0.75	0.58	0.55	0.66	0.49
C.D. (P = 0.05)	NS	NS	NS	NS	NS	NS

Oviposition

The number of eggs laid by pulse beetle (*C. chinensis* L.) was recorded at 30, 45, 60, 75 and 90 days after storage in different packaging materials with combination of silica (2%) and without silica. The mean eggs laid by female pulse beetle during entire period of storage ranged from 21.53 to 43.86 in different packaging materials with silica (2%); whereas, from 41.86to 143.53 in different packaging materials without silica. The results showed that silica proved to be best in all packaging materials. [Table 2]

Table 2: Effect of silica in interaction with different packaging materials on oviposition by pulse beetle (2020-21)

Eggs pulse beetle (No.)												
Packaging materials	**30 Days**		**45 Days**		**60 Days**		**75 Days**		**90 Days**		**Overall mean**	
Mx F	**F_1**	**F_2**	**F_1**	**F_2**	**F_1**	**F_2**	**F_1**	**F_2**	**F_1**	**F_2**	**F_1**	**F_2**
Cloth bags	44.33	14.33	72.67	26.67	99.67	40.00	146.00	52.00	183.67	64.67	109.26	39.53
Polythene bags	16.67	6.00	29.67	14.33	42.00	21.67	53.67	28.67	65.33	37.00	41.86	21.53
Jute bags	61.33	19.67	89.00	31.00	119.33	43.67	177.67	57.33	270.33	69.00	143.53	43.86
Gunny bags	33.00	11.00	58.33	24.67	97.00	37.00	133.33	48.67	167.00	57.00	97.73	35.66
S. Em.±	0.92		1.60		1.63		3.76		3.28		2.20	
C.D. (P = 0.05)	2.78		4.81		4.89		11.27		9.85		6.71	

F_1: Without silica F_2: With 2% silica

Per cent seed damage

The mean per cent seed damage by pulse beetle ranged from 3.33 to 8.53 in different packaging materials with silica (2%); Whereas, from 6.66 to 27.86 in different packaging materials without silica. The combination of silica in each packaging materials significantly reduced the seed damage by pulse beetle. [Table 4]

Table 4: Effect of silica in interaction with different packaging materials on per cent seed damage by pulse beetle (2020-21)

Per cent seed damage (%)												
Packaging materials	**30 Days**		**45 Days**		**60 Days**		**75 Days**		**90 Days**		**Overall mean**	
Mx F	**F_1**	**F_2**	**F_1**	**F_2**	**F_1**	**F_2**	**F_1**	**F_2**	**F_1**	**F_2**	**F_1**	**F_2**
Cloth bags	11.67	2.33	18.00	4.33	21.33	6.00	27.33	8.33	33.00	10.00	22.26	6.10
Polythene bags	2.67	1.00	5.67	2.00	6.33	3.67	8.67	4.33	10.33	5.67	6.66	3.33
Jute bags	15.67	3.66	22.33	6.00	28.00	8.67	33.67	11.33	39.67	13.00	27.86	8.53
Gunny bags	9.00	1.66	12.00	2.67	16.33	4.67	21.67	6.33	28.00	7.67	17.40	4.60
S. Em.±	0.45		0.72		0.55		0.82		0.94		0.69	
C.D. (P = 0.05)	1.36		2.17		1.65		2.47		2.82		2.09	

F_1: Without silica F_2: With 2% silica

Per cent weight loss

The mean per cent weight loss by pulse beetle ranged from 7.93 to 15.12 in different packaging materials with silica (2%); Whereas, from 15.09 to 37.89 in different packaging materials without silica. The combination of silica in each packaging materials significantly reduced the weight loss by pulse beetle. [Table 6]

Table 6: Effect of silica in interaction with different packaging materials on per cent weight loss by pulse beetle (2020-21)

Per cent weight loss (%)												
Packaging materials	**30 Days**		**45 Days**		**60 Days**		**75 Days**		**90 Days**		**Overall mean**	
Mx F	**F_1**	**F_2**	**F_1**	**F_2**	**F_1**	**F_2**	**F_1**	**F_2**	**F_1**	**F_2**	**F_1**	**F_2**
Cloth bags	19.10	4.10	22.54	11.31	31.08	13.78	39.40	17.55	45.61	19.22	31.54	13.19
Polythene bags	6.53	2.83	11.53	4.71	15.20	8.08	18.27	11.08	21.94	12.95	15.09	7.93
Jute bags	21.64	7.83	30.93	12.83	40.59	15.73	46.74	19.02	49.58	22.44	37.89	15.12
Gunny bags	16.47	3.33	21.04	9.58	26.51	12.88	35.58	16.10	39.70	18.86	27.86	11.67
S. Em.±	0.11		1.10		0.81		1.03		0.80		0.77	
C.D. (P = 0.05)	0.35		3.30		2.44		3.09		2.24		2.28	

F_1: Without silica F_2: With 2% silica

During present investigation, per cent weight loss in various packaging materials ranged from 2.83 to 49.58 per cent. The order of packaging materials in reducing the seed weight loss was: polythene bags >gunny bags > cloth bags > jute bags. The results on per cent weight loss exhibited in present investigation are in conformity with the finding of Lal *et al.* (2001) [4], who reported higher weight loss in local storage structures, like gunny bags and bamboo bins. Howlader *et al.* (2004) [3] also concluded highest insect population, seed damage and weight loss in gunny bags and the lowest in metal structures followed by polythene/plastic Bags.

Per cent germination

The effect on germination was recorded at 30, 45, 60, 75 and 90 DAS in terms of Per cent germination. The result present in Table (8) showed that there was no detrimental effect of silica (2%) in respective packaging materials on germination of seeds. The mean germination per cent ranges from 74.34 to 63.48 in various packaging materials with silica (2%); whereas, from 72.50 to 61.90 in various packaging materials without silica. The per cent germination was ranged from 80.67 to 70.67at 30DAS; 78.67 to 67.33 at 45DAS; 75.22 to 62.25 at 60DAS; 70.08 to 56.95 at 75DAS and 67.08 to 52.28 at 90DAS in various packaging materials irrespective to the presence or absence of the silica (2%).

Table 8: Effect of silica in interaction with different packaging materials on per cent germination on black gram (2020-21)

Per cent germination (%)												
Packaging materials	**30 Days**		**45 Days**		**60 Days**		**75 Days**		**90 Days**		**Overall mean**	
Mx F	**F_1**	**F_2**	**F_1**	**F_2**	**F_1**	**F_2**	**F_1**	**F_2**	**F_1**	**F_2**	**F_1**	**F_2**
Cloth bags	73.33	74.33	70.00	71.33	64.92	65.55	60.62	62.08	56.98	57.50	65.17	66.96
Polythene bags	79.00	80.67	77.00	78.67	72.25	75.22	69.28	70.08	64.95	67.08	72.50	74.34
Jute bags	70.67	71.33	67.33	69.33	62.25	64.22	56.95	57.75	52.28	54.75	61.90	63.48
Gunny bags	74.67	76.00	70.67	73.33	67.58	68.75	63.28	64.42	57.95	59.08	66.83	68.08
S. Em.±	0.97		1.50		1.17		1.11		4.00		0.99	
C.D. (P = 0.05)	2.93		4.49		3.53		3.35		1.33		2.99	

F_1: Without silica F_2: With 2% silica

During present investigation, per cent germination in various packaging materials ranged from 80.67 to 52.28 per cent. The order of germination observed was polythene bags > gunny bags > cloth bags > jute bags. Likewise, Ananthi *et al.* (2017) [1] reported that seed stored in polythene bag container maintained the seed quality parameters like germination without seed deterioration up to nine months of storage.

Among the various treatments used; effectiveness order of various packaging materials against pulse beetle were polythene bags > gunny bags > cloth bags > jute bags. The

oviposition by pulse beetle ranged from 6.00 to 270.33 in different packaging materials. The minimum numbers of pulse beetle eggs were found in polythene bags due to lower oxygen level, lower moister level and thickness of polythene reduced the insect penetration through outside. So, low moisture and low oxygen level were reduced the egg producing ability of pulses beetle. During present investigation, per cent seed damage in various packaging materials ranged from 1.00 to 39.67 per cent. The order of packaging materials in reducing the seed damage was: polythene bags > gunny bags > cloth bags > jute bags.

The results of Sanon *et al.* (2011) [7] confirmed the present findings; who reported that 2 layers HDPE (High density polythene) 50 kg capacity bags tightly sealed and placed in an additional woven nylon bag (triple bag) was effective in controlling the bruchids for 7 months. Similarly, Baoua *et al.* (2012) [2] also observed that the use of three-layered bag was more capable in minimizing seed damage caused by insects during storage. The findings of Tiwari *et al.* (2014) [10] also indicated that polythene bag was most suitable as compared to other material *viz.* cloth bag, aluminium foil and paper bag.

Conclusion

The result of laboratory experiment showed that use of silica (2%) in different packaging materials (polythene bags, gunny bags, cloth bags and jute bags) significantly reduce the storage losses by the infestation of pulse beetle (*C. chinensis*) during storage.

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