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Influence of hermetic storage on the survival and damage caused by *Sitophilus oryzae* on maize (*Zea mays*) and *Caryedon serratus* on groundnut (*Arachis hypogaea*)

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ABSTRACT

Experiments on *Sitophilus oryzae* (L.) and *Caryedon serratus* (Olivier) were conducted during (2009–12) at Bapatla, Andhra Pradesh, India under laboratory conditions (32±1°C and 75% r.h. Maize (*Zea mays* L.) and groundnut (*Arachis hypogaea* L.) stored in Magik bags (Coramandal fertilizers Ltd., India). The results showed zero adults, zero per cent insect damaged grains and zero grain weight loss up to six months of storage. Maize stored in Super bags (Grain Pro Ltd., Philippines) also recorded zero infestation, but grain stored in jute bags and plastic containers recorded 0.507 to 20.82% and 0.506 to 13.77% weight respectively. The number of *C. serratus* beetles on groundnut that emerged, ranged from 136.33 (Super bag) to 366 beetles (thin netted single layer jute bag). The pod damage caused by *C. serratus* was 0.75% (super bag) to 10% (thin netted single layered jute bag) at 30 d and increased to 85.4% to 100% at 180 d. The percentage viability and germination of groundnut kernels was 100% when stored in Magik bags at 180 d followed by 72% (Super bag), 70% (Nylon bag) and about 50% in the other bags (cloth and jute).

Key words: *Caryedon serratus,* Hermetic storage, Jute bags, Magik bags, Nylon bag, *Sitophilus oryzae,* Super bags

Conservation of food grains from damage and depredations by all forms of pests is of prime importance not only from the economic point of view but also for the health and general improvement of living conditions. In India, the annual storage losses were estimated as 13.98 million tonnes of food grains worth ₹ 68,450 million (1,023 million US$). Every year food grain losses due to insects alone account for nearly ₹ 12,750 million (190.55 million US$) (Mohan and Kavitharaghavan, 2008). Rice weevil [*Sitophilus oryzae* (L.)] causes losses of 57.0% in raw rice, 49.0% in parboiled rice and 19.0% in wheat (Banerjee and Nazimuddin, 1985) and losses due to peanut beetle [*Caryedon serratus* (Olivier)] were 77.1% in groundnut pods and 67.8% in kernels (Kumari et al., 2002). To avoid health and environmental hazards, hermetic storage is gaining importance in storage pest management. Hermetic storage systems rely on the atmosphere within the grain, being modified through respiration of the grain, insects and fungi. The oxygen content in the atmosphere within the grain bulk needs to be reduced to less than 3% and the carbon dioxide content increases to a level where aerobic respiration is minimized (Diep et al., 2006).

MATERIALS AND METHODS

An experiment was conducted during 2009-12 in the Department of Entomology, Agricultural College, Bapatla, Andhra Pradesh, India under laboratory conditions of 32±1°C and 75% r.h., to study the influence of hermetic storage on *S. oryzae* and *C. serratus.*

Sitophilus oryzae

Disinfested maize kernels (500 g) were filled into

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plastic containers (500 g capacity), jute bags lined with Magik bags, jute bags lined with Super Grain bags and gunny bags made of jute. Ten pairs of freshly emerged adult weevils (one day old) were released into the grain container and tightly closed. Six sets of the treatments were made in five replications to examine the effect of hermetic storage at monthly intervals for six months storage period. The first set was opened after one month; likewise the second after two months, the third after three months, the fourth after four months, the fifth after five months and the sixth set after six months.

Caryedon serratus

The treatments were Magik bags, Super Grain bags, nylon bags, cloth bags, polythene lined cloth bags, polythene lined thin netted jute bags, thick netted double layered jute bags, thin netted double layered jute bags, thick netted single layered jute bags and thin netted single layered jute bags (control) were tested similarly against *C. serratus.*

The observations were recorded on number of adults emerged, weight loss (%) and seed or pod damage (%). Viability (%) and germination (%) of groundnut seeds were also recorded by a 0.5% tetrazolium test against the infestation of *C. serratus.*

RESULTS AND DISCUSSION

Effect of hermetic storage on Sitophilus oryzae

Maize in hermetic storage of jute bags lined with Magik and Super bags recorded zero weevils during one to six months after storage period which were significantly different from storage in plastic container and jute bag alone. The highest weevil count was recorded in maize stored in jute bag alone being 2.6, 6.6, 12.6, 24.8, 37.6 and 39.0 at one to six months respectively. Maize in plastic container revealed a weevil count of 1.6, 5.6, 11.2, 20.4, 28.4 and 29.0 at one month to six months storage periods respectively. These were significantly different from each other (Fig. 1; Table 1). Hermetic storage systems rely on modifying the atmosphere within the grain through respiration of the grain, insects and fungi. In hermetic systems, the oxygen content in the atmosphere surrounding the grain inside the grain bulk is reduced, often to less than 3.0% and the carbon dioxide content increases to a level where aerobic respiration is minimized (Diep et al., 2006). Bailey (1965) also reported that the mortality of five insect species of *Rhyzopertha dominica* (Fab.)*, Tribolium castaneum* Herbst., *Oryzaephilus surinamensis* (L.), *Cryptolestes ferrugineus* (Steph.) and the larvae of *Trogoderma granarium* Everts was due to oxygen depletion (anoxia) and not by the accumulation of carbon dioxide. Storey (1978) also reported 100% mortality of adults with two days exposure on *Callosobruchus maculatus* at 1% O_2, 9–10% CO_2, the balance nitrogen. Decline in oxygen levels to 0.8, 0.6, 0.4 and 0.0% in maize with 14, 15, 16 and 17% m.c., respectively, was also reported by Martha et al. (2006). Similarly, in this experiment there were no live weevils in hermetic storage jute bags, i.e. jute bags lined with Superor Magik bags, compared to an enormous increase in weevils with heat development by fifth and sixth months of storage in jute bag and plastic containers.

Population development of *S. oryzae*, measured by a count and weight method, was zero per cent in maize stored in jute bags lined with Magik and Super bags (hermetic storage) after one to six months storage

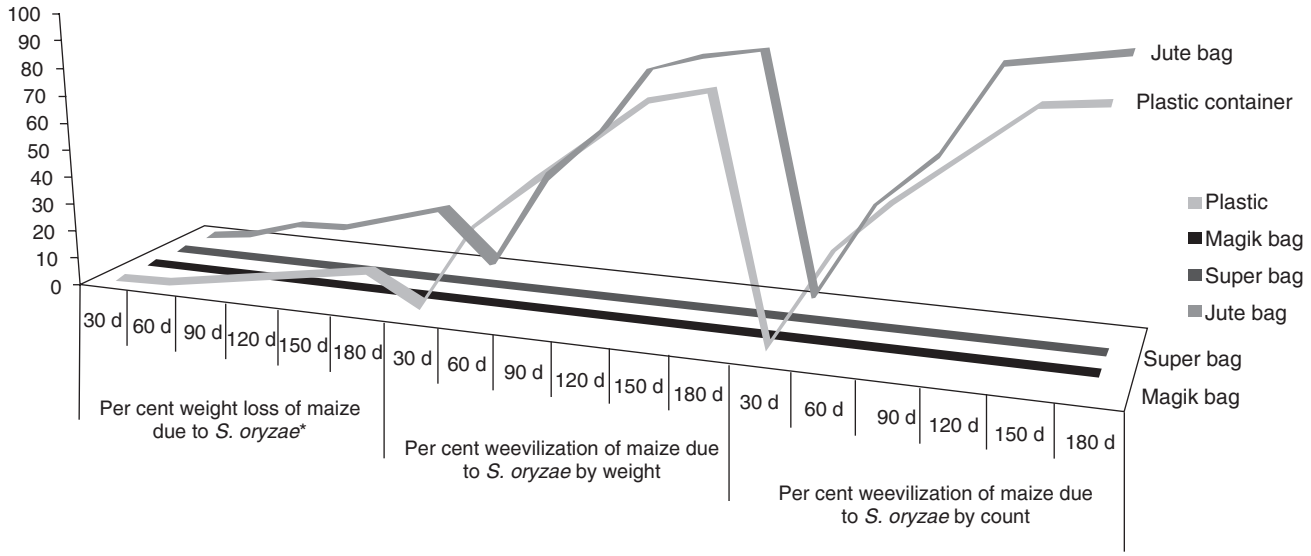

Fig. 1. Effect of hermetic storage of maize on losses caused by *Sitophilus oryzae*

Table 1 Effect of hermetic storage of maize on losses caused by *Sitophilus oryzae*

Storage structure	Storage period					
	30 d	60 d	90 d	120 d	150 d	180 d
	*Per cent weight loss of maize due to S. oryzae**					
Plastic container	0.506 (4.04)[a]	1.34 (7.34)[b]	4.53 (12.25)[b]	7.60 (15.98)[b]	11.36 (19.69)	13.77 (21.78)[b]
Magik bag	0.00 (0.00)[b]	0.00 (0.00)[c]	0.00 (0.00)[c]	0.00 (0.00)[c]	0.00 (0.00)[c]	0.00 (0.00)[c]
Super bag	0.00 (0.00)[b]	0.00 (0.00)[c]	0.00 (0.00)[c]	0.00 (0.00)[c]	0.00 (0.00)[c]	0.00 (0.00)[c]
Jute bag	0.507 (3.99)[a]	2.61 (10.16)[a]	8.77 (17.17)[a]	9.49 (17.90)[a]	14.79 (22.60)	20.82 (27.14)[a]
SEm (±)	0.26	0.26	0.44	0.41	0.27	0.21
CD (P=0.05)	0.80	0.78	1.33	1.23	0.81	0.63
	Per cent weevilization of maize due to S. oryzae by weight					
Plastic container	2.83 (9.64)[a]	34.53 (35.99)[b]	52.21 (46.27)[a]	66.24 (54.48)[b]	82.48 (65.26)[b]	87.41 (69.2)[b]
Magik bag	0.0 (0.0)[c]	0.0 (0.0)[c]	0.0 (0.0)[b]	0.0 (0.0)[c]	0.0 (0.0)[c]	0.0 (0.0)[c]
Super bag	0.0 (0.0)[c]	0.0 (0.0)[c]	0.0 (0.0)[b]	0.0 (0.0)[c]	0.0 (0.0)[c]	0.0 (0.0)[c]
Jute bag	2.08 (8.26)[b]	35.45 (36.54)[a]	53.76 (47.16)[a]	80.78 (64.01)[a]	86.57 (68.51)[a]	89.77 (71.4)[a]
SEm (±)	0.31	0.16	0.47	0.29	0.21	0.44
CD (P=0.05)	0.94	0.47	1.41	0.87	0.65	1.33
	Per cent weevilization of maize due to S. oryzae by count					
Plastic container	3.33 (10.49)[a]	38.02 (38.07) [a]	58.30 (49.78)[a]	74.96 (59.99)[b]	90.50 (72.1)[b]	92.40 (74.0)[b]
Magik bag	0.0 (0.0)[c]	0.0 (0.0)[b]	0.0 (0.0) [b]	0.0 (0.0)[c]	0.0 (0.0)[c]	0.0 (0.0)[c]
Super bag	0.0 (0.0) [c]	0.0 (0.0) [b]	0.0 (0.0)[b]	0.0 (0.0)[c]	0.0 (0.0)[c]	0.0 (0.0)[c]
Jute bag	2.63 (9.30)[b]	37.80 (37.94)[a]	56.86 (49.33) [a]	90.39 (71.97)[a]	93.20 (75.0)[a]	96.80 (79.7)[a]
SEm (±)	0.3	0.16	0.35	0.47	0.41	0.29
CD (P=0.05)	0.9	0.49	1.06	1.42	1.24	0.87

Values in parentheses are transformed values In each column values with similar alphabet do not vary significantly at P=0.05
* arc sine transformation

period. This was significantly different from storage in plastic containers and jute bags alone. The highest weevil increase by count, 3.33% and by weight, 2.83% was recorded in maize in plastic containers. This was significantly different from jute bag alone recording 2.63 and 2.08% weevil increase by count and weight method at 30 d respectively. Weevil increase in jute bags alone by weight was 35.45% significantly higher than that of plastic containers at 34.53%, but it was similar to the increase of weevil by count in jute bag and plastic containers of 37.80 and 38.02%, respectively, at 60 d.

Weevil infestation of maize by count (58.30 and 56.8%) and by weight (52.21 and 53.76%) was similar

at 90 d in plastic containers and jute bags respectively. Again there was a significant difference in insect population numbers by count in plastic containers (74.96, 90.5 and 92.4%) and by weight (66.24, 82.48 and 87.41%) compared to weevil development in jute bag alone with 90.39, 93.2 and 96.8% by count and 80.78, 86.57 and 89.77% by weight at 120, 150 and 180 d respectively (Table 1; Fig. 1).

Development of *S. oryzae* on maize in plastic containers and jute bags were similar by count and weight method however, from the fourth month onwards there was significantly higher population in jute bags alone upto six months of storage period. Khan et al. (1976) also made an interesting observation that paddy seeds under vacuum storage (2×10^{-3} to 5 mm Hg) remained completely free from insect damage while those under normal atmosphere sustained considerable damage (about 4 % of the seeds damage). There was also a reduction in seed m.c. in vacuum storage from the initial 13.73 to 7.85%, whereas the same initial m.c. was more or less maintained by the seeds stored under normal atmosphere during a storage period of 360 days.

The weight loss (%) in maize was zero when stored in jute bags lined with Magik and Super bags during one to six months storage period and were significantly different from jute bags alone with 0.50, 2.61, 8.77, 9.49, 14.79 and 20.82% weight loss as well as in plastic containers where the weight loss was 0.50, 1.34, 4.53, 7.6, 11.36 and 13.77% at one to six months storage period (Table 1; Fig. 1). Similarly, Caliboso et al. (1999) also reported minimum weight loss of rice and maize stacks with high seed viability and no aflotoxin development during the six months of hermetic storage period. Thilakarathna et al. (2006) reported 0.4% weight loss in a ferro-cement bin and 2.1% weight loss in control after six months of storage.

The materials used for storage result in hermetic conditions by depleting existing oxygen and increasing carbon dioxide from respiration by insects and grain (Bailey, 1965) resulted lower insect infestation without affecting the germination of the seed (Diep et al., 2006; Jolli et al., 2005). These studies indicate further investigations into the bio-chemical and biophysical reasons behind the successful penetration of gases through packing material used in storage.

Effect of hermetic storage of groundnut on Caryedon serratus

Adult emergence: Groundnut pods stored in Magik bag recorded zero adult emergence during one to six months of storage, which was significantly different from storage in all other types of bags. Groundnut pods stored in all different types of bags also recorded

Table 2 Effect of hermetic storage of groundnut on adult emergence of *Caryedon serratus*

Storage bags	Storage period					
	30 d	60 d	90 d	120 d	150 d	180 d
Magik bag	0 (0.00)	0 (0.71)^{a}	0 (0.71)^{a}	0 (0.71)^{a}	0 (0.71)^{a}	0 (0.71)^{a}
Super bag	0 (0.71)	15.33 (3.97)^{b}	26.33 (4.99)^{b}	59.67 (7.65)^{b}	115 (10.72)^{b}	136.33 (11.69)^{b}
Nylon bag	0 (0.71)	17.67 (4.25)^{b}	23.33 (4.84)^{b}	79.0 (8.88)^{b}	127 (11.26)^{b}	195.33 (13.98)^{bc}
Cloth bag	0 (0.71)	82.67 (9.11)^{f}	187.5 (13.60)^{d}	249.33 (15.71)^{d}	322.67 (17.91)^{d}	350 (18.71)^{d}
Polythene lined cloth bag	0 (0.71)	37 (6.11)^{bcd}	53.67 (7.29)^{bc}	107.0 (10.34)^{bc}	210.67 (14.43)^{c}	229.33 (15.10)^{c}
Polythene lined thin netted jute bag	0 (0.71)	31 (5.38)^{bc}	68.67 (8.29)^{c}	118.33 (10.83)^{bc}	217.67 (14.71)^{cd}	237 (15.36)^{c}
Thick netted double layered jute bag	0 (0.71)	50.33 (6.77)^{cde}	82.33 (9.09)^{c}	212.33 (14.57)^{d}	242 (15.46)^{cd}	278.33 (16.62)^{cd}
Thick netted single layered jute bag	0 (0.71)	68.33 (8.28)^{ef}	82.67 (9.10)^{c}	169.67 (12.87)^{cd}	241.67 (15.41)^{cd}	283.67 (16.73)^{cd}
Thin netted double layered jute bag	0 (0.71)	63 (7.96)^{def}	87.33 (9.35)^{c}	169.67 (12.89)^{cd}	239.67 (15.34)^{cd}	283.33 (16.70)^{cd}
Thin netted single layered jute bag	0 (0.71)	78 (8.80)^{ef}	161.67 (12.43)^{d}	206.33 (14.19)^{d}	299 (17.30)^{cd}	366 (19.23)^{d}
SEm±		0.68	0.87	1.03	1.04	0.91
CD (P=0.05)	NS	2.01	2.56	3.03	3.06	2.68

Table 3 Effect of hermetic storage of groundnut on% pod damage (by count) caused by *Caryedon serratus*

Storage bags	Storage period					
	30 d	60 d	90 d	120 d	150 d	180 d
Magik bag	0 (0.00)[a]	0 (0.00)[a]	0 (0.00)[a]	0 (0.00)[a]	0 (0.00)[a]	0 (0.00)[a]
Super bag	0.85 (0.49)[a]	9.92 (5.69)[ab]	42.92 (16.16)[ab]	55.33 (33.64)[b]	68.67 (43.42)[b]	82.67 (55.84)[b]
Nylon bag	0.81 (0.46)[a]	12.64 (7.26)[b]	55.76 (34.69)[bc]	90 (65.77)[c]	95.33 (73.06)[c]	100 (90.0)[c]
Cloth bag	11.52 (6.62)[b]	31.19 (18.22)[e]	75.47 (49.75)[c]	100 (90.0)[d]	100 (90.0)[d]	100 (90.0)[c]
Polythene lined cloth bag	5.78 (3.31)[ab]	16.11 (9.28)[bcd]	58.33 (40.96)[bc]	98.67 (84.58)[d]	100 (90.0)[d]	100 (90.0)[c]
Polythene lined thin netted jute bag	5.55 (3.19)[ab]	15.35 (8.84)[bc]	57.27 (36.95)[bc]	92.67 (72.08)[c]	100 (90.0)[d]	100 (90.0)[c]
Thick netted double layered jute bag	5.46 (3.13)[ab]	26.04 (15.17)[cde]	68.16 (45.21)[bc]	100 (90.0)[d]	100 (90.0)[d]	100 (90.0)[c]
Thick netted single layered jute bag	11.23 (6.45)[b]	27.42 (15.92)[de]	73.07 (47.60)[bc]	100 (90.0)[d]	100 (90.0)[d]	100 (90.0)[c]
Thin netted double layered jute bag	4.53 (2.59)[ab]	26.67 (15.49)[cde]	70.15 (44.57)[bc]	100 (90.0)[d]	100 (90.0)[d]	100 (90.0)[c]
Thin netted single layered jute bag	13.41 (7.74)[b]	34.97 (20.48)[e]	84.09 (58.78)[c]	100 (90.0)[d]	100 (90.0)[d]	100 (90.0)[c]
SEm±	1.70	3.16	9.61	4.01	1.22	0.58
CD (P = 0.05)	5.03	9.32	28.34	11.83	3.59	1.73

zero beetle emergence up to 30 days of storage and was not significantly different from other treatments (Table 2). The reason behind this is the duration of the life cycle of *C. serratus*, which is about 45 days for adult emergence. Super bags recorded a minimum number of adult emergence of *C. serratus* at 15.33, 26.33, 59.67, 115 and 136.33 at 60, 90, 120, 150 and 180 d. This was similar to nylon bags, polythene lined thin netted jute bags and polythene lined cloth bags which recorded 17.67, 23.33, 79.0, 127 and 195.33; 31, 68.67, 118.33, 217.67 and 237; 37, 53.67, 107, 201.67 and 229.33 beetles respectively. In the remaining storage bags—thick netted double and single layered jute bags and thin netted double and single layered jute bags—there were more than 50 to 78 adults of *C. serratus* emerged at 60 d, maximum being 278.33 to 366 at 180 d.

Pod damage % (by count): Pod damage (by count method) increased in all types of bags with the increase in storage period except in Magik bag which gave complete protection against pod damage from attack of *C. serratus* up to 180 days of storage and was significantly superior and different from all other types of storage bags (Table 3).

Though all types of storage bags recorded no adult emergence at 30 d, varying levels of pod damage were recorded in different bags caused by *C. serratus* larvae, which will bore into the pods immediately after hatching.

Pod damage by count was the minimum in nylon bags and Super bags at 30 d, recording 0.81 and 0.85% and 12.64 and 9.92% at 60 d, which were similar to each other. Thin netted and thick netted double layered bags, polythene lined thin netted bags and polythene lined cloth bags recorded 4.53, 5.46, 5.55 and 5.78% at 30 d; and 26.67, 26.04, 15.35 and 16.11% pod damage at 60 d respectively. Thick netted single layered bag, cloth bag and thin netted single layered bag recorded the maximum pod damage of 11.23, 11.52 and 13.41% at 30 d; and 27.42, 31.19 and 34.97% at 60 d, respectively, which were similar to each other and also with polythene lined cloth bags, polythene lined thin netted bags, thick netted and thin netted double layered bag. More than 50% pod damage by count was recorded in all types of bags except Super bags with 42.92 at 90 d. The pod damage by count was 100% in all the bags after 120 d, except Super bags with 82.67% at 150 d.

Table 4 Effect of hermetic storage of groundnut on per cent pod damage (byweight) caused by *Caryedon serratus*

Storage bags	Storage period					
	30 d	60 d	90 d	120 d	150 d	180 d
Magik bag	0 (0.00)	0 (0.00)^{a}	0 (0.00)^{a}	0 (0.00)^{a}	0 (0.00)^{a}	0 (0.00)^{a}
Super bag	0.75 (0.43)	5.98 (3.43)^{ab}	39.16 (23.06)^{ab}	61 (38.37)^{b}	76.92 (50.72)^{b}	85.4 (58.94)^{b}
Nylon bag	0.75 (0.43)	10 (5.74)^{ab}	52.67 (32.46)^{bc}	89.02 (63.63)^{c}	93.92 (70.46)^{c}	100 (90.00)^{c}
Cloth bag	10.91 (6.27)	29.41 (17.15)^{de}	77.17 (51.30)^{bc}	100 (90.0)^{d}	100 (90.0)^{d}	100 (90.0)^{c}
Polythene lined cloth bag	3.91 (2.24)	19.25 (11.12)^{bc}	57.33 (39.75)^{bc}	98.88 (85.03)^{d}	100 (90.0)^{d}	100 (90.0)^{c}
Polythene lined thin netted jute bag	5.33 (3.07)	16 (9.21)^{bc}	50.33 (31.27)^{bc}	95.21 (76.57)^{d}	100 (90.0)^{d}	100 (90.0)^{c}
Thick netted double layered jute bag	3.61 (2.07)	22 (12.76)^{cd}	58.33 (37.39)^{bc}	100 (90.0)^{d}	100 (90.0)^{d}	100 (90.0)^{c}
Thick netted single layered jute bag	9.42 (5.41)	23.16 (13.99)^{cd}	59.5 (37.29)^{bc}	100 (90.0)^{d}	100 (90.0)^{d}	100 (90.0)^{c}
Thin netted double layered jute bag	3.5 (2.01)	22.91 (13.26)^{cd}	64.17 (40.00)^{bc}	100 (90.0)^{d}	100 (90.0)^{d}	100 (90.0)^{c}
Thin netted single layered jute bag	10 (5.77)	34.83 (20.39)^{e}	85.33 (59.00)^{c}	100 (90.0)^{d}	100 (90.0)^{d}	100 (90.0)^{c}
SEm±		1.81	9.03	4.13	1.78	1.01
CD (P = 0.05)	NS	5.34	26.64	12.17	5.28	2.98

Pod damage % (by weight): Magik bags recorded no pod damage (0%) (by weight) up to the sixth month of storage (Table 4). The pods in different storage bags did not show any significant difference between them for pod damage by weight at 30 d. Minimum pod damage of 0.75% was observed in Super bags and nylon bags. The maximum damage was recorded in thin netted single layered bags and cloth bags, with 10 and 10.91% damage respectively. The remaining thin netted and thick netted double layered bags, polythene lined cloth bags, polythene lined thin netted jute bags and thick netted single layered bags recorded 3.5, 3.61, 3.91, 5.33, 9.42% damage respectively. The lowest pod damage (5.98%) was recorded in Super bags at 60 d which was similar to nylon bags (10%), polythene lined thin netted jute bags (16%) and polythene lined cloth bags (19.25%). Thick netted and thin netted double layered bag and thick netted single layered bag recorded 22, 22.91 and 23.16% pod damage and were similar to each other and also to with polythene lined cloth bag, polythene lined thin netted jute bags and cloth bag (29.41). The highest percentage of pod damage (34.83) was recorded in thin-netted single layered bags, being at par with cloth bags. More than 50% damage was observed in all the bags except in Super bags (39.16%). Pod damage of 100% by weight was recorded in all the bags after 120 d, except in Super bags with 85.4% at 150 d.

Weight loss (%): A similar trend was recorded for percentage weight loss. Magik bags recorded zero per cent weight loss up to sixth month of storage, but it increased for all other types of bags with the increase in storage period (Table 5). Super bags recorded the minimum weight loss of 0.06, 0.29, 5.03, 10.62, 15.72 and 22.75% at 30 to 180 d and was similar to that recorded in nylon bags with 0.02, 0.86, 7.29, 14.65, 31.11% at 30 d to 180 d. Polythene lined thin netted jute bags, thick netted double layered bags, polythene lined cloth bags, thin netted double layered bags, thick netted single layered bag and thin netted single layered bag recorded 0.28, 0.29, 0.47, 0.69, 1.19, 2.04 and 1.94 % weight loss respectively. Upto 5.55, 39.41, 43.18, 53.0 and 59.03% weight loss due to *C. serratus* was observed in the remaining bags at 60,

Table 5 Per cent weight loss caused by *Caryedon serratus* in different storage bags

Storage bags	Storage period					
	30 d	60 d	90 d	120 d	150 d	180 d
Magik bag	0 (0.00)^{a}	0 (0.00)^{a}	0 (0.00)^{a}	0 (0.00)^{a}	0 (0.00)^{a}	0 (0.00)^{a}
Super bag	0.06 (0.037)^{a}	0.29 (0.17)^{a}	5.03 (2.88)^{a}	10.62 (6.9)^{b}	15.72 (9.04)^{b}	22.75 (13.22)^{b}
Nylon bag	0.02 (0.01)^{a}	0.86 (0.49)^{ab}	7.29 (4.18)^{ab}	14.65 (8.43)^{b}	31.11 (18.15)^{c}	47.94 (28.74)^{c}
Cloth bag	1.94 (1.11)^{c}	4.49 (2.57)^{cd}	33.21 (19.39)^{cd}	43.85 (26.10)^{c}	53.00 (32.02)^{d}	59.03 (36.31)^{c}
Polythene lined cloth bag	0.47 (0.27)^{a}	2.14 (1.22)^{abc}	23.50 (13.63)^{bcd}	36.78 (21.58)^{c}	48.34 (28.92)^{d}	52.94 (32.06)^{c}
Polythene lined thin netted jute bag	0.28 (0.16)^{a}	1.64 (0.94)^{abc}	14.49 (8.34)^{abc}	36.78 (21.58)^{c}	46.00 (27.39)^{d}	49.82 (29.90)^{c}
Thick netted double layered jute bag	0.29 (0.17)^{a}	4.08 (2.34)^{cd}	25.44 (14.81)^{bcd}	36.61 (21.48)^{c}	51.03 (30.71)^{d}	53.12 (32.17)^{c}
Thick netted single layered jute bag	1.19 (0.68)^{b}	3.37 (1.94)^{bcd}	27.47 (16.20)^{cd}	37.72 (22.16)^{c}	51.70 (31.13)^{d}	53.53 (32.39)^{c}
Thin netted double layered jute bag	0.69 (0.39)^{ab}	3.5 (2.03)^{bcd}	30.65 (17.94)^{cd}	36.89 (21.65)^{c}	51.85 (31.30)^{d}	57.38 (35.03)^{c}
Thin netted single layered jute bag	2.04 (1.17)^{c}	5.55 (3.18)^{d}	39.41 (23.34)^{d}	43.18 (25.69)^{c}	52.65 (31.89)^{d}	57.75 (35.30)^{c}
SEm±	0.12	0.52	3.36	1.65	1.76	2.51
CD	0.37	1.53	9.92	4.87993	6.29	7.39

Values in parentheses are angular transformed values In each column values with similar alphabet do not vary significantly at P=0.05

Table 6 Effect of hermetic storage of groundnut viability of groundnut kernels

Storage bags	Storage period					
	30 d	60 d	90 d	120 d	150 d	180 d
Magik bag	100	100a	100^{a}	100^{a}	100^{a}	100^{a}
Super bag	100	98^{a}	92.67^{b}	83.33^{b}	74^{b}	72^{b}
Nylon bag	100	94^{b}	88.67^{b}c	78^{c}	72.67^{b}	70^{b}
Cloth bag	100	90^{c}	82.67^{e}	72.67^{d}	62.67^{c}	52^{c}
Polythene lined cloth bag	100	93.33^{b}	84^{cde}	71.33^{d}	64.67^{c}	51.33^{c}
Polythene lined jute bag	100	93.33^{b}	86.67^{cde}	73.33^{cd}	64.67^{c}	52^{c}
Thick netted double layered jute bag	100	93^{b}	84^{cde}	75.33^{cd}	65.33^{c}	51.33^{c}
Thick netted single layered jute bag	100	91.33^{bc}	82.67^{de}	75.33^{cd}	61.33^{c}	53.67^{c}
Thin netted double layered jute bag	100	89.33^{c}	82.67^{cde}	74.67^{cd}	65.67^{c}	52.67^{c}
Thin netted single layered jute bag	100	88.67^{c}	81.33^{de}	70.67^{d}	62.67^{c}	50.67^{c}
SEm±		0.94	1.47	1.49	1.78	1.48
CD (P=0.05)	NS	2.78	4.35	4.39	5.25	4.36

90, 120, 150 and 180 d.

Raghuram (2010) reported complete protection of maize stored in Magik bags and Super bags up to six months of storage with respect to number of weevils emerged, grain damage by count and weight method and % weight loss. He also recorded a maximum number of weevils, highest maize grain damage and weight loss in jute bags.

Similar results were observed in the present experiment when groundnut pods were stored in Magik bags only. But groundnuts stored in Super bags recorded 15.33 to 136.33 number of adults, 0.85 to 82.67% pod damage by count, 0.75 to 85.4% pod damage by weight and 0.06 to 22.75% weight loss in one to six months storage period. This may be due to high inter-granular space between groundnut pods compared to that of maize grains. Moreover, the beetles were able to make holes in the Super bags but not in Magik bags. Anandhi et al. (2007) also recorded the maximum number of adults and per cent weight loss in jute bags, followed by jute bag lined with polythene and muslin cloth bags and 100% infestation in all three types of bags. Mishra et al. (2008) also reported that polythene bags, jute bags and polythene coated jute bags were less effective and recorded a higher percentage weight loss in pods.

Viability (%) and germination (%): Pods stored in different types of bags showed 100% germination and viability at one month of storage and decreased with the increase in storage period except in case of Magik bags which maintained 100% viability and germination throughout the storage period up to six months, may be owing to complete protection from *C. serratus* (Table 6).

Super bags showed 98, 92.67, 83.33, 74 and 72% viability at 60 to 180 d, being significantly different from other types of storage bags. The remaining bags also showed 62.67 and 50.67% viability up to 150 and 180 d.

Super bags showed the highest germination of 96.67, 92.33, 82.33, 74.0 and 71.67% next to Magik bags at 60, 90, 120, 150 and 180 d. The remaining bags showed 61.33 to 72.67% and 50.67 to 69.33% germination upto 150 and 180 d respectively. Germination and viability of groundnut kernels were 100% when pods were stored in Magik bags where there was no infestation and damage by *C. serratus*. However, germination and viability of kernels reduced with the increased pod damage due to *C. serratus* in Super bags and conventional storage bags. Diep et al. (2006) reported maintenance of the highest germination in hermetic bags, with an average germination of 96%. Jolli et al. (2005) reported inhibition of germination in cloth bags in accordance with the level of infestation.

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