Effects of packaging material and moisture contents on pulse beetle infestation under different storage conditions in chickpea

Abstract

Background: Chickpea (*Cicer arietinum* L.) is an important pulse crop grown globally for its nutritional richness and versatility which offers a significant source for both carbohydrates and protein. Chickpea seeds face a significant threat from various insect pests among these pulse beetles or bruchids (Callosobruchus spp.) stand out as the most destructive, inflicting damage ranging from 50% to 60% during storage. Bruchids are considered minor pests in the field, but they pose a serious threat during storage, leading to both quantitative and qualitative losses.

Method: The present investigation was carried out with the objective of studying the influence of ambient and cold storage conditions on storability and to assess the pest infestation (pulse beetle) under ambient and cold storage conditions in two chickpea varieties viz., JG-11 (desi) and NBeG-119 (kabuli). The seed was thoroughly sun dried to two moisture levels of seven and nine percent and stored in gunny and grain pro bags (hermetic bags). Gunny bags were kept at ambient storage as well as in the cold storage, while grain pro bags were stored at ambient storage conditions only as these are the hermetic bags and the dry chain technology concept holds good for storage at ambient conditions only.

Results: Highest % seed damage (12.11 % in JG-11 and 13.00 % in NBeG-119) was noticed in seeds stored with nine per cent moisture content while, the lowest % seed damage (9.50 % in JG-11 and 9.83 % in NBeG 119) was recorded in seeds with seven per cent moisture content. After 8 months of storage highest per cent fecundity (151.66 and 144.66 in JG-11 and 145.00 and 138.50 in NBeG-119) was recorded in seeds stored in gunny bags kept at ambient storage with nine and seven per cent moisture respectively, followed by the seed stored in grain pro bags at ambient storage with nine percent seed moisture (9.667 in JG-11 and 7.833 in NBeG-119) and no fecundity was recorded in seeds stored in gunny bag at cold storage. At the end of storage period highest adult emergence was recorded in seeds stored in gunny bag at ambient storage with nine (196.83 in JG-11 and 217.17 in NBeG-119) and seven (187.83 in JG-11 and 207.83 in NBeG-119) per cent seed moisture followed by the seed stored in grain pro bags at ambient storage with nine percent seed moisture (11.67 in JG-11 and 13.00 in NBeG-119) and no adult emergence was recorded in seeds stored in gunny bag at cold storage (0.00 in JG-11 and 0.00 in

NBeG-119) with seven and nine percent moisture at the end of the storage. Highest weight loss % (2.019% in JG-11 and 1.866% in NBeG-119) was recorded in seeds stored with nine per cent moisture content. While, the lowest weight loss % (1.679% in JG-11 and 1.772% in NBeG-119) was noticed in seeds stored with seven per cent moisture at the end of storage period

Key words: Chickpea, gunny bag, grainpro bag, pulse beetle, cold storage

Introduction

Chickpea (*Cicer arietinum* L.) is a vital pulse crop grown globally, known for its nutritional richness and versatility. It offers a significant source of both carbohydrates and protein, with its protein quality often considered superior to that of other pulses. Besides its macronutrient content, chickpeas are also noteworthy for their array of potential health benefits and micronutrient richness. They contain essential vitamins such as riboflavin, niacin, thiamin, folate, and β-carotene, a precursor to vitamin A, which are crucial for overall health and well-being (Jukanti *et al*., 2012). India has maintained its position as the leading producer of chickpeas worldwide, with a substantial production volume. In India, chickpea (*Cicer arietinum* L.) is cultivated in an area of 9.99 million ha, with the production of 11.91 million tons and with the productivity of 1192 kg/ha during 2021-22 (IIPR, 2021 Annual report).

There are two primary types of cultivated chickpeas: Desi and Kabuli, each with distinct characteristics. Desi chickpeas, also known as microsperma types, are characterized by pink flowers, anthocyanin pigmentation on stems, and seeds with colored and thick coats. On the other hand, Kabuli chickpeas, or macrosperma types, feature white flowers, lack anthocyanin pigmentation on stems, and possess seeds with white or beige colors. Kabuli chickpeas typically have a distinct ram's head shape, thin seed coat, and smooth seed surface. Desi chickpeas dominate approximately 80–85% of the total chickpea cultivation area and are primarily grown in regions across Asia and Africa. In contrast, Kabuli chickpeas are predominantly cultivated in West Asia, North Africa, North America, and Europe.

Chickpea seeds face a significant threat from various insect pests, with as many as sixty-five different species known to cause losses during both pre and post-harvest stages (Lal, 1985). Among these pests, pulse beetles or bruchids (Callosobruchus spp.) stand out as the most destructive, inflicting damage ranging from 50% to 60% in chickpea seeds during storage (Ramzan *et al*., 1990). While bruchids are considered minor pests in the field, they pose a serious threat during storage, leading to both quantitative and qualitative losses (Casewell, 1961; German *et al*., 1987). Their impact is particularly pronounced in legume seeds, including chickpeas, where they

cause extensive grain and seed quality deterioration (Gahukar and Reddy, 2018; Stathers *et al*., 2020). The bruchids are fast breeders, have high fecundity under stored conditions. Seed loss due to *Callosobruchus* species was reported as high as 30 % in India and seed damage up to the extent of 40 to 50 %.

The storage losses of seeds in terms of quality and quantity were hundred per cent under unhygienic storage conditions. Greater variations in quality of chickpea seeds are evident in both kabuli and desi varieties during storage. One of the important factors influencing the seed storage are the temperature and the seed moisture content. Dry Chain technology wherein, the seeds were thoroughly sundried to the possible lowest moisture content and packed air tight hermetic bag so as to prevent further moisture absorption from atmosphere (Bradford *et al*., 2018).

One of the major problems during the pulse storage is loss of viability and damage of pulse seeds from insect infestation at ambient storage conditions when stored in gunny bags. Therefore, the present investigation was undertaken to find out the effectiveness of dry chain technology (hermetic containers-grain pro bags) which were stored at ambient conditions and compared to seed packed in gunny bags stored at both ambient and cold storage conditions for loss of seed viability and insect infestation (pulse beetle) in chickpea varieties.

MATERIAL AND METHODS

The present investigation was carried out with the objective of studying the influence of ambient and cold storage conditions on storability and to assess the pest infestation (pulse beetle) under ambient and cold storage conditions in two chickpea varieties viz., JG-11 (desi) and NBeG-119 (kabuli). The seed was thoroughly sun dried to two moisture levels of seven and nine percent and stored in gunny and grain pro bags (hermetic bags). Gunny bags were kept at ambient storage as well as in the cold storage, while grain pro bags were stored at ambient storage conditions only as these are the hermetic bags and the dry chain technology concept holds good for storage at ambient conditions only. Freshly harvested bengal gram seed cv. JG-11 was obtained from the TSSDC and cv. NBeG-119 was obtained from the Regional Agricultural Research station, Nandyal, A.P. The experiment was carried out at the department of Seed Science and Technology, Seed Research and Technology Centre, PJTSAU, Rajendranagar during 2021-2022.The seed samples were drawn at random from all the bags at bimonthly intervals for analyzing the seed damage %, fecundity %, weight loss% and adult emergence percent. The design of the experiment for the laboratory study adopted was mixed factorial completely randomized design. The seed samples were drawn at random from all the bags at bimonthly intervals for analyzing the seed infestation parameters such as adult emergence, seed damage, weight loss and fecundity.

Seed damage (%)

At the bimonthly intervals 400 seeds were taken from each replication and the number of damaged seeds was counted and the mean number of damaged seeds was calculated and expressed in percentage.

$$\text{Seed damage (\%)} = \frac{\text{No. of damaged seeds per sample x 100}}{\text{Total no. of the seeds taken per sample (400)}}$$

Fecundity(no.)

At the bimonthly intervals 10g of representative seed sample was drawn from each sub replication of the treatments and the number of eggs laid by adult bruchid on the surface of the seeds was counted with the help of hand lens and the mean number of eggs per 10 g was calculated.

Adult emergence (no.)

The F_1 progeny emerged from each treatment at 60 days after release were counted and adult beetles were discarded daily to avoid further mating and egg laying. The process was continued till they completely cease to emerge. The mean adult emergence was worked out by pooling the data.

Weight loss (%)

The final weight of the seed was recorded from each replication of the treatment at bimonthly intervals and the weight loss due to insect infestation was calculated by deducting the final weight from the initial weight and expressed in percent weight loss.

$$\text{Weight loss (\%)} = \frac{\text{Initial weight of sample (g) – final weight of sample (g) x100}}{\text{Initial weight of the sample}}$$

RESULTS AND DISCUSSION

Seed Damage (%)

The % seed damage caused due to the infestation of the *Callosobruchus chinensis* in two chickpea varieties viz., JG-11 (desi variety) and NBeG-119 (kabuli variety) with two levels of seed moisture content as influenced by packaging materials (gunny and grain pro) kept at different storage conditions (ambient and cold) was presented here. There is no significant

difference observed in seed moisture content up to six months of the storage but showed significant difference after sixth months of storage. Highest % seed damage (12.11 % in JG-11 and 13.00 % in NBeG-119) was recorded in seeds stored with nine per cent moisture content while, the lowest % seed damage (9.50 % in JG-11 and 9.83 % in NBeG 119) was noticed in seeds with seven per cent moisture content (Table. 1).

The seeds stored in gunny bag kept at ambient storage noticed significantly highest % seed damage (27.33 % in JG-11 and 28.58% in NBeG 119) followed by seeds stored in grain pro bags kept at ambient storage (4.75 % in JG-11 and 5.25 % in NBeG 119). While, significantly lowest % seed damage (0.33 % in JG-11 and 0.41% in NBeG 119) was noticed in seeds stored in gunny bags kept at cold storage conditions after 10 months of storage (Table.1). Packaging materials at different storage conditions showed significant difference throughout the storage period.

After 10 months of storage highest % seed damage was recorded in seeds stored in gunny bags kept at ambient storage with nine (30.00%) and seven (24.67 %) per cent seed moisture followed by the seed stored in grain pro bags kept at ambient storage with nine percent seed moisture (6.00 %) and the lowest % seed damage was recorded in seeds stored in gunny bags kept at cold storage with seven (0.33%) and nine (0.33%) percent moisture at the end of the storage (Table 1).

The extent of seed damage caused due to the insect infestation is more in kabuli variety compared to desi variety and the results obtained were in agreement with Erler *et al*. (2009) wherein they reported that out of 11 genotypes tested, only one (ICC-4969) exhibited complete resistance to C. *maculatus* in both free-choice and no-choice tests.

Fecundity per cent

The % fecundity of the seeds as influenced by packaging materials in different storage conditions and different seed moisture content on chickpea and their interaction effects in JG-11 and NBeG-119 are presented in Table 2. No significant difference was observed for seed moisture content up to four months of the storage but showed significant difference after four months of storage. Highest fecundity per cent (53.66 in JG-11 and 49.889 in NBeG-119) was recorded in seeds stored with nine per cent moisture content. While, the lowest fecundity per cent (51.44 in JG-11 and 48.778 in NBeG-119) was noticed in seeds stored with seven per cent moisture after 8 months of storage (Table 2). Packaging materials at different storage conditions showed significant difference throughout the storage period. The seeds stored in gunny bags kept at

ambient storage noticed significantly highest per cent fecundity (148.167 in JG-11 and 141.750 in NBeG-119) followed by seeds stored in grain pro bags kept at ambient storage (9.167 in JG-11 and 6.250 in NBeG-119). While, significant low per cent fecundity (0.333 in JG-11 and 0.00 in NBeG-119) was noticed in seeds stored in gunny bags kept at cold storage after 8 months of storage (Table 2).

Interaction of packaging materials and different storage conditions showed no significant difference up to four months of the storage but showed significant difference after four months of storage. After 8 months of storage highest per cent fecundity (151.66 and 144.66 in JG-11 and 145.00 and 138.50 in NBeG-119) was recorded in seeds stored in gunny bags kept at ambient storage with nine and seven per cent moisture respectively, followed by the seed stored in grain pro bags at ambient storage with nine percent seed moisture (9.667 in JG-11 and 7.833 in NBeG-119) and no fecundity was recorded in seeds stored in gunny bag at cold storage (Table 2). Fecundity of *Callosobruchus chinensis* on chickpea is more in desi variety (JG-11) when compared with the kabuli variety (NBeG-119) representing its ovipositional preference and Raghuwanshi *et al.* (2016) reported that maximum number of eggs were laid on chickpea genotype ICCV-07301 (34.35) and minimum numbers of eggs (17.3) were laid on genotype ICCV-990126 by *C.chinensis*.

Adult emergence

The adult emergence caused due to the infestation of the *Callosobruchus chinensis* on chickpea and its level of damage are recorded. The adult emergence of the seeds as influenced by packaging materials in different storage temperatures and different seed moisture content on chickpea and their interaction effects are presented in Table 3.

Seed moisture content showed no significant difference up to four months of the storage but showed significant difference after fourth month of storage. Highest adult emergence per cent (69.50 in JG-11 and 76.22 in NBeG-119) was recorded in seeds stored with nine per cent moisture content. While, the lowest adult emergence per cent (66.22 in JG-11 and 73.61 in NBeG-119) was noticed in seeds stored with seven per cent moisture at the end of storage period table 3 and figure 3.

The seeds stored in gunny bags in ambient storage noticed significantly highest adult emergence (192.33 in JG-11 and 212.50) followed by seeds stored in grain pro bag at ambient storage (11.25 in JG-11 and 12.25 in NBeG-119). While, significantly no adult emergence (0.00 in JG-11 and 0.00 in NBeG-119) was noticed in seeds stored in gunny bag in cold storage at the end of storage period are presented in table 3 and figure 3.

Interaction of packaging materials in different storage conditions and seed moisture content showed no significant difference up to four months of the storage but showed significant difference after fourth month. At the end of storage period highest adult emergence was recorded in seeds stored in gunny bag at ambient storage with nine (196.83 in JG-11 and 217.17 in NBeG-119) and seven (187.83 in JG-11 and 207.83 in NBeG-119) per cent seed moisture followed by the seed stored in grain pro bags at ambient storage with nine percent seed moisture (11.67 in JG-11 and 13.00 in NBeG-119) and no adult emergence was recorded in seeds stored in gunny bag at cold storage (0.00 in JG-11 and 0.00 in NBeG-119) with seven and nine percent moisture at the end of the storage are presented in table 3. Adult emergence is more in the kabuli variety of (NBeG-119) chickpea when compared with desi variety (JG-11) and results are in agreement with Shafique *et al*. (2005) who reported that genotypes CM 3142-2/92 (12.33), CM 88 (13.67), CM 3142-3/92 (14.33), CM-72 (18.67), and Pb 91 (18.33) recorded lower number of adult emergence which indicating resistance to *C. analis* in chickpea.

Weight Loss % in JG-11 (Desi Variety)

The weight loss % of the seeds was influenced by packaging materials in different storage conditions and different seed moisture content on chickpea and their interaction effects are presented in Table 4.

Seed moisture content showed no difference up to four months of the storage but showed significant difference after fourth month to the end of the storage. Highest weight loss % (2.019% in JG-11 and 1.866% in NBeG-119) was recorded in seeds stored with nine per cent moisture content. While, the lowest weight loss % (1.679% in JG-11 and 1.772% in NBeG-119) was noticed in seeds stored with seven per cent moisture at the end of storage period are presented in table 4 and depicted in figure 4.

Packaging materials at different storage conditions showed significant difference throughout the storage period. The seeds stored in gunny bag in ambient storage noticed significantly highest weight loss % (4.908 in JG-11 and 4.703 in NBeG-119) followed by seeds stored in grain pro bag in ambient storage (0.640 in JG-11 and 0.754 in NBeG-119). While, the significantly no weight loss % (0.000) was noticed in seeds stored in gunny bag in cold storage at the end of storage period in JG-11 and in NBeG-119 are presented in table 4 and figure 4.

Interaction of packaging materials in different storage conditions and seed moisture content showed no significant difference up to four months of the storage but showed significant

difference after fourth month to the end of the storage. At the end of storage period highest weight loss was recorded in seeds stored in gunny bag at ambient storage with nine (5.388 %) and seven (4.428%) in JG-11 and nine(4.812%) and seven (4.593%) in NBeG-119, per cent seed moisture followed by the seed stored in grain pro bag at ambient storage with nine (0.670 %) and seven (0.610%) in JG-11 and (0.785%)in NBeG-119 , percent seed moisture and the no weight loss was recorded in seeds stored in gunny bag at cold storage (0.00%) with seven and nine percent moisture respectively in JG-11 and NBeG-119 at the end of the storage are presented in table 4 Weight loss is more in NBeG-119 (kabuli variety) compared to JG-11 (Desi variety) and similar results were obtained by Raghuwanshi *et al*. (2016) who reported that significantly higher weight loss (24.98 %) in SG-98310 followed by SG-950226 (16.64 %) in bean. Least weight loss (5.78 %) was observed in SG-97311 closely followed by SG-98004 (6.36 %) which was resistant varieties. Similar results were also shown by Lema, 1994 and Shaheen *et al*., 2006 in chickpea. The treatment with the insecticide deltamethrin showed minimum or no insect infestation in chickpea and the results are in agreement with (D. K. Jaiswal *et al*., 2019).

CONCLUSION:

At the end of storage period low % seed damage, lowest fecundity, a least number of adult emergence and low weight loss percent were recorded in both the chickpea seed varieties stored in gunny bag kept at cold storage conditions with seven and nine percent moisture at the end of the storage followed by seed stored in grainpro bags kept at ambient conditions and there is no significant difference among the gunny bags kept at cold storage conditions and grainpro bags kept at ambient conditions for the above parameters studied.

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Fig.1 Influence of seed moisture content and packaging materials kept at different storage conditions on seed damage (%) during storage in chickpea varieties

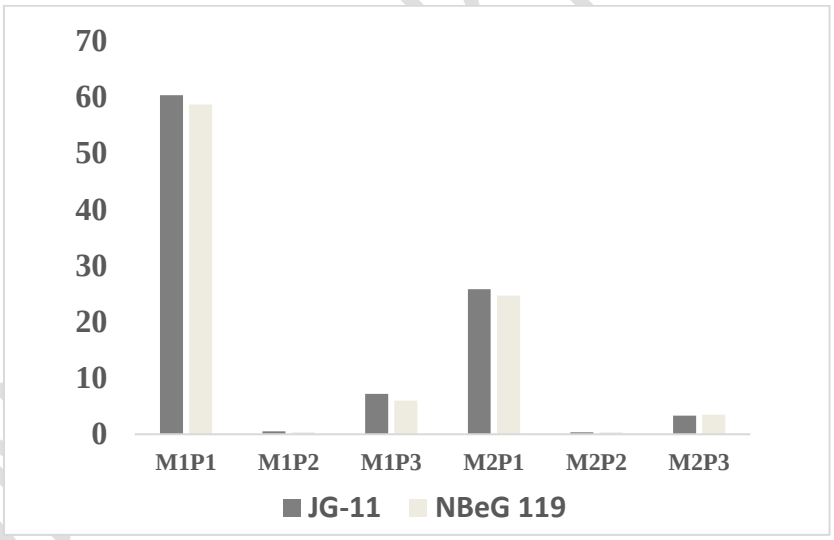


Fig. 2 Influence of seed moisture content and packaging materials kept at different storage conditions on fecundity during storage in chickpea varieties

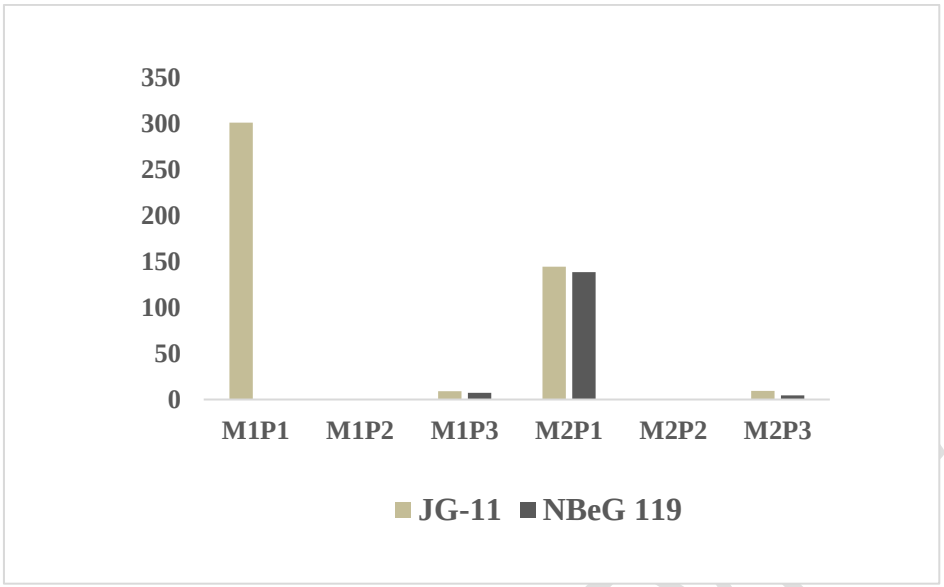


Fig. 3. Influence of seed moisture content and packaging materials kept at different storage conditions on adult emergence during storage in chickpea varieties.

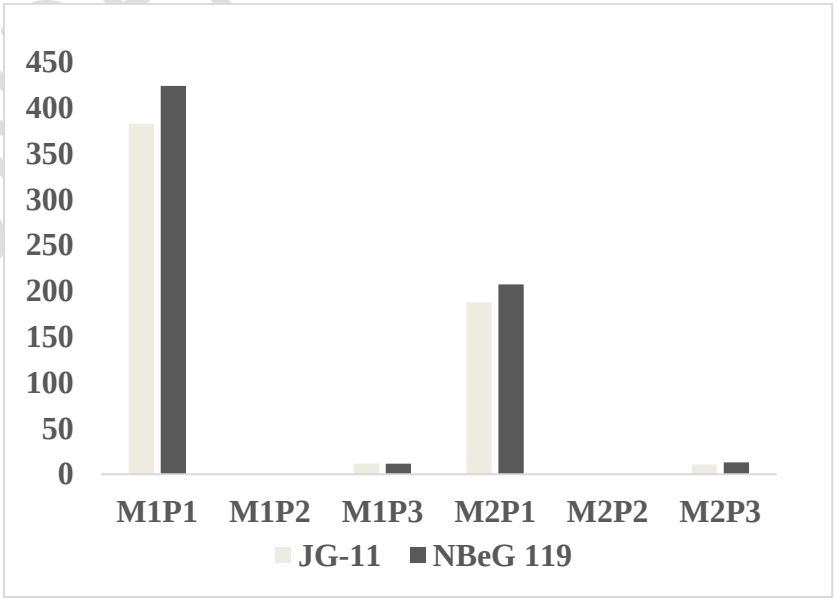
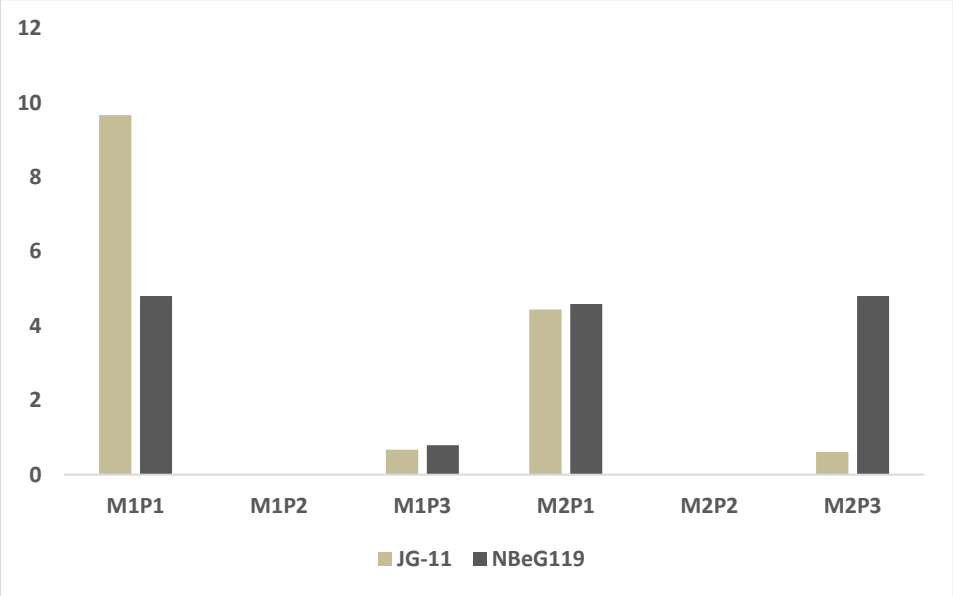


Fig. 4. Influence of seed moisture content and packaging materials kept at different storage conditions on weight loss (%) during storage in chickpea varieties.



P1= Gunny bags kept in ambient storage, P2= Grain pro bags kept in ambient storage, P3= Gunny bags kept in cold storage, M1= Nine percent seed moisture, M2= Seven percent seed moisture

Table 1 Influence of seed moisture content and packaging materials in different storage conditions on seed damage during storage of chickpea varieties JG-11 (Desi Variety) and NBeG 119 (Kabuli Variety)

Factors	SEED DAMAGE (%)											
	NBeG 119	JG-11	NBeG 119	JG-11	NBeG 119	JG-11	NBeG119	JG-11	NBeG 119	JG-11	NBeG119	JG-11
	0 MAS		2 MAS		4 MAS		6 MAS		8 MAS		Mean	
Seed Moisture Content												
M1 (9%)	0.00	0.00	1.69	1.84	3.78	3.92	7.33	7.28	13.00	12.11	5.16	5.03
M2 (7%)	0.00	0.00	1.64	1.67	3.78	3.56	6.50	6.33	9.83	9.50	4.35	4.21
Mean	0.00	0.00	1.67	1.76	3.78	3.74	6.92	6.81	11.42	10.8	4.79	4.62
SEm (±)	0.00	0.00	0.006	0.006	0.018	0.012	0.026	0.024	0.038	0.035	-	-
CD (0.05)	0.00	0.00	0.019	0.019	0.052	0.036	0.076	0.070	0.113	0.102	-	-
	Packaging materials											
P1 (Gunny kept at ambient	0.00	0.00	4.75	5.16	10.67	10.79	18.66	18.08	28.58	27.33	12.53	12.26
P2 (Gunny kept at cold storage)	0.00	0.00	0.00	0.00	0.00	0.00	0.42	0.33	0.42	0.33	0.17	0.13
P3 (Grainpro bag at ambient	0.00	0.00	0.20	0.15	0.67	0.42	1.67	2.00	5.20	4.70	1.57	1.46
Mean	0.00	0.00	1.67	1.76	3.78	3.74	6.92	6.81	11.42	10.81	4.76	4.62
SEm (±)	0.00	0.00	0.010	0.010	0.027	0.018	0.039	0.036	0.058	0.052	-	-
CD (0.05)	0.00	0.00	0.028	0.028	0.079	0.054	0.115	0.105	0.169	0.153	-	-
	Packaging materials × Seed Moisture content											
M1P1	0.00	0.00	9.17	10.73	19.67	21.83	37.33	37.33	60.33	58.67	25.30	25.71
M1P2	0.00	0.00	0.00	0.00	0.00	0.00	0.67	0.33	0.50	0.33	0.23	0.13
M1P3	0.00	0.00	0.50	0.17	1.00	0.50	2.17	2.33	7.17	6.00	2.17	1.80
M2P1	0.00	0.00	4.92	4.89	11.00	10.33	18.17	17.00	25.83	24.67	11.99	11.38
M2P2	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.33	0.33	0.33	0.10	0.13
M2P3	0.00	0.00	0.00	0.13	0.33	0.33	1.17	1.67	3.33	3.50	0.97	1.13
Mean	0.00	0.00	1.67	1.76	3.78	3.74	6.92	6.81	11.42	10.81	4.76	4.62
SEm (±)	0.00	0.00	0.019	0.040	0.054	0.125	0.078	0.072	0.115	0.104		
CD (0.05)	0.00	0.00	0.056	0.118	0.157	0.368	0.229	0.210	0.338	0.306		

Table 2. Influence of seed moisture content and packaging materials in different storage conditions on seed damage during storage of chickpea in JG-11 (Desi variety) and NBeG 119 (Kabuli variety)

Factors	Fecundity											
	JG-11	NBeG 119	JG-11	NBeG 119	JG-11	NBeG 119	JG-11	NBeG 119	JG-11	NBeG 119	JG-11	NBeG 119
	0 MAS		2 MAS		4 MAS		6 MAS		8 MAS		Mean	
Seed Moisture Content												
M1	0.00	0.00	15.28	14.94	30.94	28.67	51.39	47.11	53.67	49.89	30.26	28.12
M2	0.00	0.00	14.94	15.39	31.50	28.94	45.72	46.78	51.44	48.78	28.72	27.98
Mean	0.00	0.00	15.11	15.17	31.22	28.81	48.56	46.94	51.14	49.93	29.21	28.05
SEm (±)	0.00	0.00	0.058	0.048	0.114	0.093	0.112	0.080	0.136	0.159		
CD (0.05)	0.00	0.00	0.169	0.141	0.333	0.272	0.328	0.234	0.398	0.467		
Packaging materials with different storage conditions												
P1	0.00	0.00	44.25	44.67	139.08	83.92	139.58	135.50	148.17	141.75	94.27	81.17
P2	0.00	0.00	0.50	0.00	0.58	0.00	0.33	0.00	0.33	0.00	0.35	0.00
P3	0.00	0.00	0.58	0.83	6.00	2.50	9.17	5.33	9.17	6.25	4.983	2.983
Mean	0.00	0.00	15.11	15.17	31.22	28.81	48.56	46.94	51.14	49.93	29.206	28.052
SEm (±)	0.00	0.00	0.08	0.07	0.168	0.139	0.433	0.120	0.203	0.239		
CD (0.05)	0.00	0.00	0.25	0.21	0.491	0.408	1.270	0.351	0.597	0.700		
	Seed Moisture × Packaging material with different storage conditions											
M1P1	0.00	0.00	89.33	0.00	175.33	0.00	292.67	0.00	301.33	0.00	171.73	0.00
M1P2	0.00	0.00	0.50	0.00	0.67	0.00	0.50	0.00	0.33	0.00	0.40	0.00
M1P3	0.00	0.00	0.67	0.83	3.83	3.33	6.67	6.00	9.00	7.33	4.03	3.60
M2P1	0.00	0.00	43.83	45.33	91.33	83.50	131.17	134.33	144.67	138.50	82.20	80.33
M2P2	0.00	0.00	0.50	0.00	0.50	0.00	0.67	0.00	0.33	0.00	0.40	0.00
M2P3	0.00	0.00	0.50	0.83	2.67	1.67	5.33	4.67	9.33	4.67	3.57	2.37
Mean	0.00	0.00	15.11	15.17	31.22	28.81	48.56	46.94	51.14	49.93	29.206	28.052
SEm (±)	0.00	0.00	0.173	0.144	0.341	0.28	0.335	0.236	0.407	0.478		
CD (0.05)	0.00	0.00	0.506	0.423	0.999	0.86	0.983	0.691	1.193	1.402		
C.V (%)	0.00	0.00	6.86	5.71	6.55	5.79	4.14	3.06	4.65	5.81		
SEm (±)	0.00	0.00	0.345	0.289	0.681	0.556	0.670	0.478	0.814	0.955		
CD (0.05)	0.00	0.00	1.013	0.847	1.999	1.632	1.966	1.403	2.387	2.800		

Table 3. Influence of treatment, seed moisture content and packaging materials in different storage conditions on Adult emergence during storage of chickpea in JG-11 (Desi Variety)

Factors	Adult emergence											
	JG-11	NBeG 119	JG-11	NBeG 119	JG-11	NBeG 119	JG-11	NBeG 119	JG-11	NBeG 119	JG-11	NBeG 119
	0 MAS		2 MAS		4 MAS		6 MAS		8 MAS		Mean	
Seed Moisture Content												
M1	0.00	0.00	43.56	54.89	56.22	63.67	63.39	71.94	69.50	76.44	46.53	53.39
M2	0.00	0.00	44.50	53.83	57.67	59.67	60.11	70.17	66.22	73.39	45.70	51.41
Mean	0.00	0.00	44.03	54.36	56.94	61.67	61.75	71.06	67.86	74.92	46.12	52.401
SEm (±)	0.00	0.00	0.097	0.135	0.111	0.300	0.135	0.150	0.200	0.237		
CD (0.05)	0.00	0.00	0.284	0.395	0.327	0.881	0.395	0.441	0.587	0.696		
Packaging materials with storage conditions												
P1	0.00	0.00	132.08	163.08	164.92	178.75	177.33	203.25	192.33	212.50	133.33	151.52
P2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
P3	0.00	0.00	0.00	0.00	5.92	6.25	7.92	9.92	11.25	12.25	5.02	5.68
Mean	0.00	0.00	44.03	54.36	56.94	61.67	61.75	71.06	67.86	74.92	46.12	52.401
SEm (±)	0.00	0.00	0.145	0.202	0.167	0.451	0.202	0.226	0.300	0.356		
CD (0.05)	0.00	0.00	0.425	0.592	0.490	1.322	0.593	0.662	0.881	1.044		
	Seed Moisture content × Packaging material with different storage conditions											
M1P1	0.00	0.00	261.33	329.33	320.67	362.67	357.33	405.33	382.67	424.00	264.40	304.27
M1P2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M1P3	0.00	0.00	0.00	0.00	5.17	6.167	7.83	9.67	11.67	11.50	4.93	5.47
M2P1	0.00	0.00	133.50	161.50	166.33	172.67	172.33	200.33	187.83	207.167	132.00	106.90
M2P2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M2P3	0.00	0.00	0.00	0.00	6.67	6.33	8.00	10.17	10.83	13.00	5.10	5.90
Mean	0.00	0.00	44.03	54.36	56.94	61.67	61.75	71.06	67.86	74.92	46.12	52.401
SEm (±)	0.00	0.00	0.290	0.404	0.334	0.901	0.404	0.451	0.601	0.712		
CD (0.05)	0.00	0.00	0.851	1.184	0.980	2.643	1.186	1.323	1.761	2.088		

Table 4. Influence of seed moisture content and Packaging materials in different storage conditions on weight loss during storage of chickpea in JG-11 (Desi variety)

Factors	Weight loss											
	JG-11	NBeG 119	JG-11	NBeG 119	JG-11	NBeG 119	JG-11	NBeG 119	JG-11	NBeG 119	JG-11	NBeG 119
	0 MAS		2 MAS			4 MAS		6 MAS		8 MAS		Mean
Seed Moisture Content												
M1	0.00	0.00	0.38	0.45	1.10	1.13	1.58	1.69	2.02	1.87	1.02	1.03
M2	0.00	0.00	0.31	0.36	0.94	1.13	1.43	1.53	1.68	1.77	0.87	0.96
Mean	0.00	0.00	0.35	0.41	1.02	1.13	1.51	1.61	1.85	1.82	0.95	0.99
SEm (±)	0.00	0.00	0.005	0.009	0.019	0.015	0.006	0.005	0.006	0.003		
CD (0.05)	0.00	0.00	0.016	0.027	0.057	0.045	0.019	0.014	0.018	0.008		
Packaging materials with different storage conditions												
P1	0.00	0.00	0.90	1.05	2.68	2.92	3.93	4.19	4.92	4.70	2.48	2.57
P2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
P3	0.00	0.00	0.14	0.17	0.38	0.47	0.59	0.64	0.64	0.75	0.35	0.41
Mean	0.00	0.00	0.35	0.41	1.02	1.13	1.51	1.61	1.85	1.82	0.95	0.99
SEm (±)	0.00	0.00	0.008	0.014	0.029	0.023	0.010	0.007	0.009	0.004		
CD (0.05)	0.00	0.00	0.024	0.040	0.085	0.067	0.028	0.021	0.027	0.012		
	Seed Moisture content × Packaging material with different storage conditions											
M1P1	0.00	0.00	1.59	1.18	5.18	2.93	7.27	4.42	9.67	4.81	4.74	2.67
M1P2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M1P3	0.00	0.00	0.16	0.19	0.48	0.47	0.60	0.66	0.67	0.79	0.38	0.42
M2P1	0.00	0.00	0.82	0.92	2.53	2.90	3.72	3.96	4.44	4.59	2.30	2.47
M2P2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M2P3	0.00	0.00	0.12	1.18	0.28	2.93	0.58	4.42	0.61	4.81	0.32	2.67
Mean	0.00	0.00	0.35	0.41	1.02	1.13	1.51	1.61	1.85	1.82	0.95	0.99
SEm (±)	0.00	0.00	0.016	0.027	0.058	0.046	0.019	0.014	0.019	0.008		
CD (0.05)	0.00	0.00	0.048	0.080	0.170	0.135	0.056	0.042	0.055	0.025		
C.V (%)	0.00	0.00	7.62	5.37	6.49	4.39	7.58	5.38	6.03	2.78		
SEm (±)	0.00	0.00	0.033	0.054	0.116	0.092	0.038	0.029	0.037	0.017		
CD (0.05)	0.00	0.00	0.097	0.160	0.340	0.269	0.112	0.085	0.109	0.049		