

## Effect of Desiccants on Seed Storability of Rice and Black gram Under Coastal Environment

TRAMANADANE

Seed Technology Research Unit, Department of Plant Breeding and Genetics  
PJN College of Agriculture & Research Institute, Karaikal 609 603, Puducherry (UT)  
raman\_nadane@rediffmail.com

**ABSTRACT:** A study was undertaken to develop a simple, cost effective and practical seed storage technique using water absorbing desiccants for rice and black gram under coastal environment of Karaikal district of Puducherry (UT) during the year 2013. One kilogram of freshly harvested seeds of rice cv. ADT (R) 45 and black gram cv. ADT 3 were dried to moisture content of below 10% and stored in different containers with or without desiccants. In all the desiccant treatments, a seed: desiccant ratio of 1:0.350 was followed. Observations on seed moisture content (%), seed germination percentage, total seedling length (cm), vigour index, seed infection (%), insect infestation (%) and number of dead and live insects were undertaken at monthly intervals. The results revealed that a significant reduction or desorption of moisture in seeds was noticed during storage. Among the desiccants, seeds stored with "Zeolite" drying beads had lost higher moisture content followed by silica gel and rice husk. The desiccants didn't have a significant influence on the vigour and viability of seeds under ambient storage over a period of four months in rice. However, a significant reduction in germination was observed in black gram. Irrespective of the crops, a significant increase in seed infection was noticed during storage. Further, the level of infection in black gram was twice that of rice after four months of storage. Among the desiccants, drying beads and silica gel were found to be superior desiccants by registering the lowest seed infection in both the crops. Similarly, the desiccants had significant control over the multiplication of live insects in rice. Among the desiccants, silica gel, drying beads and rice husk were found to be the superior by registering significantly lesser number of live insects than other desiccants. The effect of desiccants on dead insects was also similar to live insects. Since, the effect of rice husk and charcoal on seed infection and infestation are comparable with drying beads, such low cost desiccants may be used with periodic regeneration for safe storage of high volume crop seeds.

**Keywords:** Desiccants, Seed moisture, Seed storage container, Seed vigour

Rice (*Oryza sativa* L.) is the staple food crop of the 60% of world's population. It is the second most widely consumed cereal in the world next to wheat. In India, rice is grown in 43.86 mha, the production level is 104.80 million tons and the productivity is about 2390 kg/ha [1]. Pulses, also called grain legumes, are extensively grown in tropical regions of the world for centuries as a major protein rich crop bringing considerable improvement in human diet [2]. India is one of the major pulse growing countries in the world with a total area of 23.10mha and total production of

17.16 million tons [3]. Among the different pulses, black gram (*Vigna mungo* L.) is a rich source of protein which is one of the essential nutrients of human diet. In India, black gram is grown in 31.29 lakh ha with production of 18.29 lakh tons with productivity of 595 kg/ha [3].

High quality seed is basic and crucial agricultural input that can determine the commercial success of a crop variety. Maintenance of high seed quality during storage is the most important aspect in many crops. In India 80% of

Received : January 2017

Revised : May 2017

Accepted : June 2017

crops seeds are kept in storage for at least one planting season and the remaining 15-20 percent is carried over for subsequent sowing due to various reasons [4]. However, seed storage can be a major problem in India as it is located in tropical and subtropical regions, where the combination of high temperature and high relative humidity, causes rapid deterioration of seed quality. In general, a seed's longevity is reduced by approximately half for every 1 per cent increase in seed moisture content (water content as a per cent of fresh weight) or 5°C increase in temperature, and the effects are additive [5].

Traditionally, crop seeds are sun-dried and stored under ambient conditions in porous bags. Such seeds lose viability rapidly in warm, humid climates primarily due to the high seed moisture content increase. It is not possible to reduce seed moisture contents to safe storage levels with ambient or even heated-air drying under high humidity conditions. In addition, even if seeds are dried by heated air driers, they will regain moisture from the air when stored in porous bags. They are also susceptible to moulds and insects when stored at high moisture content. Based on latest development in the area of seed storage, these problems can be overcome by drying seeds to low moisture contents using inexpensive hermetic containers and Zeolite drying beads. Using drying beads, seeds can be quickly and efficiently dried to safe storage moisture contents, and storing seeds in hermetic containers not only maintains low moisture contents, it also prevents losses due to rodents, insects and moulds. Seed desiccant drying beads are a simple, inexpensive and reusable for seed drying in humid climates [6].

A major advantage of bead drying is that it is not dependent upon the sun or other direct sources of energy and it is independent of the ambient humidity. It does require the use of moisture-proof containers in which the beads and seeds can be enclosed. Since, only few works have been carried out on the use of drying beads for safe storage that too in horticultural crops, it is necessary to study the process of drying with beads for safe storage of high volume crops like paddy and black gram, which are the major crops, grown in this region. Hence, the present investigation was

undertaken to develop a simple, cost effective and seed storage technique using water absorbing desiccants so as to ensure proper maintenance of seed moisture during storage and to determine the effect of drying beads on seed quality during storage under high humid coastal region of Karaikal district of Puducherry Union Territory.

## MATERIALS AND METHODS

Each one kilogram of freshly harvested seeds in both rice cv. ADT (R) 45 and black gram cv. ADT 3 were dried to moisture content of less than 10 per cent by sun drying followed by forced air drying using seed dryer (OSWA) and stored in different containers with or without desiccants @ 1:0.350 ratio (seed : desiccant) in two replications as detailed below:

T<sub>1</sub>: Seeds stored in 400 gauge polythene bags, T<sub>2</sub>: Seeds stored in rigid plastic containers, T<sub>3</sub>: Seeds stored in rigid plastic containers with silica gel T<sub>4</sub>: Seeds stored in rigid plastic containers with Zeolite drying beads, T<sub>5</sub> Seeds stored in rigid plastic containers with rice husk, T<sub>6</sub> Seeds stored in rigid plastic containers with charcoal and T<sub>7</sub> Seeds stored in rigid plastic containers with CaCl<sub>2</sub>.

The rice husk, charcoal and CaCl<sub>2</sub> are comparatively cost effective and cheaper desiccants and hence they were included in the study for comparison. The following seed quality parameters were recorded at monthly intervals:

*Seed moisture content (%)*: The moisture content was estimated by hot air oven method [7]. The samples were ground to powder using mortar and pestle, weighed in a moisture bottle and placed in a hot air oven maintaining 130±2°C for 2 h. Seed samples were then taken out from the oven and cooled in a desiccator for 30 min. The moisture content was estimated using the following formula and expressed in percentage.

$$\text{Moisture content (\%)} = \frac{M_2 - M_3}{M_2 - M_1} \times 100$$

Where, M<sub>1</sub> = Weight of empty bottle with lid

M<sub>2</sub> = Weight of bottle + seed before drying

M<sub>3</sub> = Weight of bottle + seed after drying

**Germination (%):** Four replicates of 100 seeds each taken at random were placed for germination in roll towel in the germination room maintained at a temperature of  $25 \pm 1^\circ\text{C}$  and  $95 \pm 3$  per cent relative humidity (RH) and evaluated on the 14<sup>th</sup> day for rice and 7<sup>th</sup> day for black gram [5]. All the normal seedlings were counted and expressed as germination per cent.

**Total seedling length (cm):** At final count, ten normal seedlings in each replication were taken at random and the total seedling length was measured from tip of the primary leaf to tip of the primary root and the mean values were expressed in cm.

**Vigour index:** The vigour index of the seedling was computed using the following formula suggested by Abdul-Baki and Anderson [8] and expressed in whole number.

Vigour index = Mean Germination (%)  $\times$  Mean of total seedling length (cm)

**Seed infection (%):** The seed infection was recorded in four replicates of 15 seeds for rice and 10 seeds for black gram in each treatments using Blotter method and expressed in percentage.

**Insect infestation (%):** The insect infestation was observed based on kernel damage in 400 seeds of each replication in all the treatments and expressed in percentage.

**Presence / absence of live and dead insects:** The presence of live and dead seeds in one kilogram seeds of each replication in all the treatments was recorded.

**Data Analysis:** The data from various experiments were analysed by the F-test for significance following the methods described by Panse and Sukhatme [9].

## RESULTS AND DISCUSSION

The high initial viability is a pre-requisite for improving seed longevity in storage. Many authors have shown that the moisture content at which seeds were stored had a significant effect on seed longevity [10,11]. All seeds are hygroscopic, including those with impermeable seed coats, once the physical barrier has been breached, seeds

**Table 1. Effect of desiccants on seed moisture content (%) and seed germination (%) during storage in rice cv. ADT (R) 45 and black gram cv. ADT 3**

Treatments	Seed germination (%)															
	Rice						Black gram									
	Initial	2MAS	4MAS	Mean	Initial	2MAS	4MAS	Mean	Initial	2MAS	4MAS	Mean				
T <sub>1</sub>	9.31	9.34	9.24	9.30	9.27	9.18	8.75	9.07	95.5	96.5	93.8	95.27	95.0	90.8	87.3	91.03
T <sub>2</sub>	9.31	9.16	9.00	9.16	9.27	9.09	8.73	9.03	95.5	95.0	95.3	95.27	95.0	91.0	87.0	91.00
T <sub>3</sub>	9.31	7.90	7.60	8.27	9.27	7.34	7.18	7.93	95.5	93.3	93.3	94.03	95.0	93.0	89.0	92.33
T <sub>4</sub>	9.31	7.47	6.97	7.92	9.27	6.91	6.10	7.43	95.5	94.5	91.8	93.93	95.0	91.5	84.0	90.17
T <sub>5</sub>	9.31	8.50	7.91	8.57	9.27	7.30	8.13	8.23	95.5	96.5	89.3	93.77	95.0	95.5	83.0	91.17
T <sub>6</sub>	9.31	7.75	8.14	8.40	9.27	7.01	7.85	8.04	95.5	94.8	95.0	95.10	95.0	91.5	81.8	89.43
T <sub>7</sub>	9.31	8.74	8.84	8.96	9.27	8.24	8.23	8.58	95.5	95.3	92.5	94.43	95.0	91.5	79.3	88.60
Mean	9.31	8.41	8.24	8.24	9.27	7.87	7.85	8.24	95.50	95.13	93.00	94.43	95.00	92.11	84.49	88.60
CD (p=0.05)	T	S	TxS	TxS	T	S	TxS	T	NS	S	TxS	T	T	S	TxS	NS
	0.23	0.15	0.41	0.41	0.17	0.11	0.29	0.29	1.01	1.01	NS	NS	NS	1.62	4.29	NS

NS: Non-significant

MAS: Months after storage

automatically absorb or desorb moisture by diffusion along a water potential gradient between the seed and the surrounding air. In the present investigation, significant reduction or desorption of moisture in seeds was noticed during storage (Table 1). Among the desiccants, seeds stored along with "Zeolite" drying beads had lost more moisture content to the tune of 25.13 and 34.20 per cent followed by silica gel (18.36 and 22.55 %) and charcoal (15.03 and 12.30%), in rice and black gram, respectively. However, the rate of reduction was very high during 2<sup>nd</sup> month and then a decline in rate of reduction was noticed in all the desiccants except "Zeolite" drying beads, indicated that beads will continue to absorb water until all of their pores are filled, up to 20 to 25% of their initial weight [12]. The weather data also indicated that during second month of storage (January-February, 2013) the RH was increased to 94 per cent and temperature fell down to 29.8 to 30.9 °C as against 89 per cent RH and 32.7 to 36.0°C temperatures during March-April, 2013 (Table 2). Further, the pores in the "Zeolite" drying beads are only large enough to accommodate water molecules, preventing other compounds from entering and eventually blocking water absorption. In addition, "Zeolite" drying beads will absorb their full capacity across all RHs, while silica gel is much less effective at low RH levels that are best for storing seeds [6]. Sadik and White [13] observed that silica gel and toasted rice were the most efficient desiccants and toasted grains of wheat, maize and soya bean were also used successfully as desiccants, but proved to have less drying capacity than rice.

The results of desiccants on seed vigour and viability *viz.*, seed germination, seedling length and

vigour index revealed that in both the crops the desiccants didn't have a significant influence on the vigour and viability after four months of storage (Table 1 & 3). However, a significant reduction in germination was observed due to period of storage in black gram to the tune of 10 per cent as against two per cent in rice, indicated that inherently pulses are poor storers than cereals. The results on seedling length didn't show significant reduction in both the crops since the period of storage was only four months. However, a reduction in seed vigour in terms of vigour index was observed in black gram due to reduced germination over period of storage.

Interesting results were obtained on seed health status of rice and black gram seeds stored with desiccants. Though, the crop seeds were free from seed infection initially, a significant increase in infection was noticed in both the crops during storage and the level of infection in black gram was twice that of rice after four months of storage (Table 4). The probable reason could be the internally seed borne microflora might have proliferated during the later periods of storage utilizing the carbohydrate content of the seeds irrespective of containers. Among the desiccants, drying beads on par with silica gel was found to be superior desiccants by registering the least seed infection in both the crops. The other desiccants *viz.*, calcium chloride and rice husk were effective only in rice and black gram, respectively. The results are in line with the findings of Asbrouck and Taridno [14] in *Cucumis sativum* (L.).

Similarly, a significant increase in infestation was noticed at the end of 2<sup>nd</sup> month itself in rice, while the black gram seeds were totally free from

**Table 2.** The weather parameters prevailed during the period of experimentation at PAJANCOA & RI, Karaikal

Month & Year	Temperature (°C)		Relative humidity (%)	
	Max	Min	Max	Min
December, 2012	29.4	22.5	92	71
January, 2013	29.8	20.8	94	65
February, 2013	30.9	21.7	94	60
March, 2013	32.7	22.8	94	61
April, 2013	36.0	26.1	89	60

(Source: Agromet Observatory, PAJANCOA & RI, Karaikal)

**Table 3. Effect of desiccants on seedling length (cm) and vigour index during storage in rice cv. ADT (R) 45 and black gram cv. ADT 3**

Treatments	Seedling length (cm)															
	Rice							Black gram								
	Initial	2MAS	4MAS	Mean	Initial	2MAS	4MAS	Mean	Initial	2MAS	4MAS	Mean	Initial	2MAS	4MAS	Mean
T <sub>1</sub>	24.54	24.44	23.51	24.16	34.83	33.88	33.22	33.98	2344	2358	2205	2302	3309	3076	2900	3095
T <sub>2</sub>	24.54	25.48	23.93	24.65	34.83	34.31	34.97	34.70	2344	2421	2281	2348	3309	3122	3042	3158
T <sub>3</sub>	24.54	25.93	25.60	25.36	34.83	35.29	35.57	35.23	2344	2419	2388	2384	3309	3282	3166	3252
T <sub>4</sub>	24.54	26.56	26.39	25.83	34.83	35.99	35.67	35.50	2344	2510	2423	2425	3309	3293	2996	3199
T <sub>5</sub>	24.54	25.71	25.87	25.37	34.83	34.33	34.58	34.58	2344	2481	2310	2378	3309	3279	2870	3153
T <sub>6</sub>	24.54	25.53	24.75	24.94	34.83	35.63	34.81	35.09	2344	2420	2351	2372	3309	3260	2847	3139
T <sub>7</sub>	24.54	25.48	25.14	25.05	34.83	35.93	35.23	35.33	2344	2428	2325	2366	3309	3288	2794	3130
Mean	24.54	25.59	25.03	25.05	34.83	35.05	34.86	35.33	2344	2434	2326	2366	3309	3229	2945	3130
CD (p=0.05)	T	S	TxS	NS	T	S	TxS	NS	T	S	TxS	NS	T	S	TxS	NS
MAS: Months after storage	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS: Non-significant

**Table 4. Effect of desiccants on seed infection (%) and insect infestation (%) during storage in rice cv. ADT (R) 45 and black gram cv. ADT 3**

Treatments	Seed infection (%)															
	Rice							Black gram								
	Initial	2MAS	4MAS	Mean	Initial	2MAS	4MAS	Mean	Initial	2MAS	4MAS	Mean	Initial	2MAS	4MAS	Mean
T <sub>1</sub>	0.00	3.33	6.67	3.33	0.00	5.56	12.22	5.93	0.00	0.88	3.13	1.34	0.00	0.00	0.13	0.04
T <sub>2</sub>	0.00	2.22	6.67	2.96	0.00	4.44	10.00	4.81	0.00	3.63	2.00	1.88	0.00	0.00	0.00	0.00
T <sub>3</sub>	0.00	1.11	3.33	1.48	0.00	2.22	8.87	3.70	0.00	1.88	0.00	0.63	0.00	0.00	0.00	0.00
T <sub>4</sub>	0.00	2.22	0.00	0.74	0.00	2.22	4.44	2.22	0.00	0.75	0.00	0.25	0.00	0.00	0.00	0.00
T <sub>5</sub>	0.00	3.33	3.33	2.22	0.00	2.22	6.67	2.96	0.00	2.38	0.00	0.79	0.00	0.00	0.00	0.00
T <sub>6</sub>	0.00	2.22	5.56	2.59	0.00	4.44	8.89	4.44	0.00	1.38	1.25	0.88	0.00	0.00	0.00	0.00
T <sub>7</sub>	0.00	1.11	3.33	1.48	0.00	2.22	12.22	4.81	0.00	1.13	1.88	1.00	0.00	0.00	0.00	0.00
Mean	0.00	2.22	4.13	2.22	0.00	3.33	9.04	4.81	0.00	1.72	1.38	1.00	0.00	0.00	0.13	0.04
CD (p=0.05)	T	S	TxS	T	T	S	TxS	T	T	S	TxS	T	T	S	TxS	T
MAS: Months after storage	0.84	0.55	1.45	0.98	0.98	0.64	1.69	0.56	0.56	0.37	0.98	0.98	NS	NS	NS	NS

NS: Non-significant

infestation even after four months of storage, irrespective of treatments (Table 4). However, after four months after storage in rice, seeds stored with desiccants *viz.*; silica gel, drying beads and rice husk had nil infestation and emphasized the importance of continuous reduction in moisture during storage in order to minimize the risk of insect infestation. Similar finding was observed by Keshavulu *et al.* [12] in green gram. Among the insect-pests, bruchids are well known to inflict postharvest loss to stored legumes, primarily through consumption of the resource, and secondarily through the qualitative deterioration of the commodity or reduced seed stock viability [15]. In the present investigation, observation on live insects during storage revealed that the desiccants had significant control over the multiplication of live insects in rice. Among the desiccants, silica gel, drying beads and rice husk were proved to be the best for having significantly lesser number of live insects than other desiccants. Keshavulu *et al.* [12] also opined that seeds stored with Zeolite or silica gel were protected from bruchids infestation and damage by restricting their multiplication. *Rhizopertha dominica* and Angoumois grain moth (*Sitotroga cerealella* (Olivier)) were the major insect pests found in rice seeds and *Callosobruchus* spp. in black gram.

A rapid multiplication of live insects was noticed in  $\text{CaCl}_2$  desiccant after four months of storage indicated that the desiccation property of such desiccant might have lost and needs to be regenerated (Table 5). Similarly, the higher number of live insects in seeds stored in plastic container without desiccants than polythene bags was also indicated that moisture content in such container was conducive for rapid multiplication of insects and emphasised the importance of desiccant drying of seeds during storage. In black gram, only two treatments *viz.*; seeds stored in polythene container ( $T_1$ ) and plastic container with  $\text{CaCl}_2$  ( $T_7$ ) had live insects and rest of the treatments were absolutely free from live insects. With respect to number of dead insects, nearly 10 fold increase was observed in rice seed storage as against three fold in black gram during storage. However, the effect of desiccants was similar to live insects as discussed elsewhere in this Chapter. With the advancement in drying technology using drying

Table 5. Effect of desiccants on live and dead insects (No./kg) during storage in rice cv. ADT (R) 45 and black gram cv. ADT 3

Treatments	Live insects (No./kg)						Dead insects (No./kg)									
	Rice			Black gram			Rice			Black gram						
	Initial	2MAS	4MAS	Mean	Initial	2MAS	4MAS	Mean	Initial	2MAS	4MAS	Mean	Initial	2MAS	4MAS	Mean
$T_1$	0	2	12	4.67	0	2	2.5	1.50	0	2	7	3.00	0	1	1	0.67
$T_2$	0	50	121	57.00	0	0	0	0.00	0	2	36	12.67	0	0	0	0.00
$T_3$	0	1	1	0.67	0	0	0	0.00	0	1	2	1.00	0	0	0	0.00
$T_4$	0	0	1	0.33	0	0	0	0.00	0	1	0	0.33	0	0	0	0.00
$T_5$	0	0	1	0.33	0	0	0	0.00	0	1	2	1.00	0	1	0	0.33
$T_6$	0	2	21	7.67	0	0	0	0.00	0	5	18	7.67	0	0	0	0.00
$T_7$	0	19	400	139.67	0	12	8	6.67	0	9	150	53.00	0	0	4	1.33
Mean	0.00	10.57	79.57		0.00	2.00	1.50		0.00	3.00	30.71		0.00	0.29	0.71	
CD (p=0.05)	T	S	TxS		T	S	TxS		T	S	TxS		T	S	TxS	
	6.03	3.95	10.47		0.54	0.35	0.93		3.11	2.04	5.39		0.35	0.23	0.60	

MAS: Months after storage

beads with regenerability this technique becomes practically feasible especially for drying seeds of high value low volume crops, hybrids and gene banks, considering the cost of beads. Since, the effect of rice husk and charcoal on seed infection and infestation are comparable with drying beads, such low cost desiccants may be used with periodical regeneration at bimonthly intervals for safe storage of low value high volume crop seeds.

### CONCLUSION

It could be concluded that seeds can be rapidly dried to low moisture contents by mixing with Drying Beads and sealing them in a suitable airtight bag or box. The final moisture content reached will depend on the initial capacity of the beads for water, the initial moisture content of the seeds and bead-to-seed ratio. Alternatively, rice husk and charcoal can be used as low cost desiccants with periodical regeneration. Further work is required to determine a protocol for calculating optimum bead-to-seed ratio to reliably dry seeds to target moisture contents.

### ACKNOWLEDGEMENTS

The authors sincerely acknowledge the helping hands extended by M. Veeramani, V. Veerappan, M. Venkatraman, M. Vengadesh, K. Venkatesan, the students of PAJANCOA & RI, Karaikal for recording observations in lab experiments.

### REFERENCES

1. ANONYMOUS (2016). Agricultural Statistics at a glance- 2015. Government of India Ministry of Agriculture & Farmers Welfare Department of Agriculture, Cooperation & Farmers Welfare Directorate of Economics and Statistics.
2. DAS A, M BISWAS AND KK GHOSH (2010). Genetic divergence in green gram (*Vigna radiata* L.). *Journal of Agronomy*, 9(3): 126-130.
3. TIWARI AK AND AK SHIVHARE (2016). Pulses in India: Retrospect and Prospects, Publication No.: DPD/Pub.1/Vol. 2/2016 : Published by the Director, Govt. of India, Ministry of Agri. & Farmers Welfare, Directorate of Pulses Development, Vindhyachal Bhavan, Bhopal, M.P. 462004.
4. PRAMOD R PATIL (2013). Studies on impact of Packaging materials and desiccants on seed quality and storability of hybrid paddy (*Oryza Sativa* L.). M.Sc. (Ag.), Thesis, Department of Seed Science and Technology, University of Agricultural Sciences, Bangalore 560 065.
5. HARRINGTON JF (1973). Problems of seed storage. In: Heydecker W, editor, *Seed Ecology*, Butterworths, London, pp. 251-264.
6. HAY FR, P THAVONG, P TARIDNO AND S TIMPLE (2012). Evaluation of zeolite seed 'Drying Beads®' for drying rice seeds to low moisture content prior to long-term storage. *Seed Science & Technology*, 40: 374-395.
7. ISTA (1999). International rules for seed testing. International Seed Testing Association, Bassersdorf, Switzerland. *Seed Science & Technology*, 27: Supplement rule, 27-31.
8. ADBUL-BAKI AA AND JD ANDERSON (1973). Viability and leaching of sugars from germinating barley. *Crop Science*, 1: 31-34.
9. PANSE VG AND P SUKHATME (1985). Statistical methods for agricultural workers. Indian Council of Agricultural Research, New Delhi.
10. ELLIS RH, TD HONG, EH ROBERTS AND KL TAO (1990). Low moisture content limits to relations between seed longevity and moisture. *Annals of Botany*, 65: 493-504.
11. ZHENG GH (1994). Ultra-dry seed storage: Possible improved strategies and technology for germplasm conservation. *Chinese Biodiversity*, 2: 61-65.
12. KESHAVULU KUNUSOTH, PEETAMBAR DAHAL, JOHAN VAN ASBROUCK AND KENT J BRADFORD (2012). New Technology for Postharvest Drying and Storage of seeds. *Seed Times*, 5(2): 33-38.
13. SADIK S AND JW WHITE (1982). True potato seed drying over rice. *Potato Research*, 25: 269-272.
14. ASBROUCK JV AND P TARIDNO (2009). Fast field drying as a method to maintain quality, increase shelf life and prevent post harvest infections on *Cucumis sativum* L. *Asian Journal of Food and Agro-Industry*, 2009, Special Issue, p. 133-137.
15. SALUNKHE D, KSS KADAM AND JK CHAVAN (1985). Post-harvest biotechnology of food legumes. CRC Press, Boca Raton, FL, p. 160.