Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; 9(5): 1198-1202
Received: 06-06-2020
Accepted: 04-08-2020

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Standardization of ultra- seed drying of okra cv. Kashi Kranti with Zeolite beads and silica gel

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DOI: https://doi.org/10.22271/phyto.2020.v9.i5q.12388

Abstract
Ultra-dry storage, also called low moisture content storage, is a technique for decreasing seed moisture content to below 5-6 per cent using different methods and then stored hermetically at ambient temperatures. Though sun drying is common practice to dry the seeds, it is difficult to bring down seed moisture where high humidity and high temperature is frequently fluctuating. Use of seed dryer also a best alternative to reduce the seed moisture. But it may affect the viability due to temperature fluctuation at the time of seed drying. Zeolite beads (aluminum silicate) and silica gel are desiccants, which can be utilized to Ultra- dry the seeds even in fluctuated temperature and RH without affecting quality of seeds. In this study, standardization of the drying method performed by mixing okra cv. Kashi Kranti seeds with zeolite beads and silica gel, separately, in the ratio of 1:0.5, 1:1, 1:2 and 1:3 (seed: desiccant, by weight) in an air tight container and kept at room temperature. Initial moisture content of seeds (10.5%) was estimated by hot air oven method. Seeds were separated from desiccant and estimated for moisture content after 24h, 48h, 72h, 96h and 120h of drying. Moisture content of the seeds was noted down at every 24h interval. At the end of the experiment, final moisture content of dried seeds was estimated. It was observed that seed drying with zeolite beads was faster than silica gel. Significantly higher moisture content was removed from seeds by zeolite beads, and final moisture content of seeds dried with zeolite beads reached 4.59% in 1:3 ratio, which was higher moisture elimination than seeds dried with silica gel in the same ratio 6.21%. Since, hard seed formation is a problem in over dried okra seeds, germination test were conducted to know the germination (%) and vigour of dried seeds. Germination test reveals no reduction in germination (%) and no hard seed formation even in 1:3 ratio of seeds with zeolite beads. More than 80% germination was observed in all drying conditions and non-dried control which was on par with each other's. Further work is necessary to know the storability of ultra-dried seeds under air tight condition.

Keywords: Okra, zeolite beads, silica gel, drying and germination

Introduction
Ultra-dry storage, also called low moisture content storage, is a technique for decreasing seed moisture content to below 5-6 per cent using different methods and then stored hermetically at ambient temperatures. Though sun drying is common practice to dry the seeds, it is difficult to bring down seed moisture where high humidity and high temperature is frequently fluctuating. And sun drying is also very labor intensive and time taking process. It may also cause adverse effect on seeds quality. Especially, in northern parts of India and also, in colder regions of world where the sunshine hours was low. Use of seed dryer is also a best alternative to reduce the seed moisture. But it may affect the viability due to temperature fluctuation at the time of seed drying.

Alternatively desiccant drying is another option. Zeolite beads (aluminum silicate) and silica gel are desiccants, which can be utilized to Ultra- dry the seeds. Silica gel, Betonite and some salts like calcium sulphate, calcium chloride, sodium chloride have been used for drying of seed. It has been found efficient in reducing moisture content of seed (Xiorong *et al.* 1998, Zheng *et al.* 2001, Hu *et al.* 2002, Zeng *et al.* 2006). Normally desiccant drying is very slow process. Also though some desiccants like silica gel can be regenerated by heating, there is loss of water holding capacity of silica gel due to polymerization after repeated heating. These methods therefore make a non-viable option. Recently, Zeolite beads have been developed which can be used as drying desiccant (Asbrouckand Taridno 2009). Zeolite beads have a higher affinity for water than silica gel even at low humidity levels. Also, there is no loss of water holding capacity of drying beads after repeated regeneration process. This is in contrast to silica gel, which loses effectiveness with repeated regeneration.

The Zeolite beads have an extremely high capacity to adsorb water, even at very low air humidity, making them optimal drying material. The adsorption process is fully reversible and of purely physical nature. The beads can be regenerated indefinitely by heating to elevated temperature. Drying beads are modified ceramic materials (aluminum silicates and zeolite) that specifically absorb water molecules and hold them very tightly in their microscopic pores. These beads are available in 5 and 8 mm sizes. These beads are non-toxic and essentially inert, like ceramics.

Thus this experimental investigation was carried out to standardize the ultra seed drying method using zeolite beads and silica gel in okra seeds var. Kashi kranti. Since, this experiment have done in rice seeds (Hay, F. *et al.*, 2012) [3] and some other crops like tomato (Peter J. *et al.*, 2014) [6], Sorghum (Manish KV *et al.*, 2015) [10], that the present investigation was done on Okra var. kashi kranti which is a major vegetable crop of India.

India is in second place to China in vegetable production with an annual production of 184.40 Million tonnes which is increased from 101.2 Million Tonnes since 2004-05 to 2017-2018 as depicted in FIG. (Horticultural statistics at a glance, 2018) [1]

Vegetables play a vital role for nutritional and economic and food security, especially in India, where major part of population is vegetarian. Our demand of vegetables will be 225 million tonnes by 2020 and 350 million tonnes by 2030 (Anonymous 2011).

In India, okra is grown in an area of 509 m ha with an average productivity of 12 metric tonnes/ha and production of 6094.9 million tonnes. Whereas, in Uttar Pradesh it occupies an area of 22.93 million hectares with an average productivity of 13.40 metric tonnes/ha and production of 307.29 million tones. (Horticultural statistics at a glance, 2018) [1]

Materials and Methods

The popular variety of okra cv kashi kranti freshly harvested seeds were procured from Indian Institute of Vegetable Research, Varanasi, Uttar Pradesh. The experiment was conducted in Seed testing Laboratory in Department of Genetics and plant breeding, Naini agricultural Institute, Prayagraj, Uttar Pradesh.

After procurement of seeds, the initial moisture content of the seeds were obtained using standard hot air oven method, (ISTA, 1993). The initial germination percentage and vigour index of seeds were obtained by standard germination test using between paper method (ISTA, 1924).

Then, the seeds were mixed with desiccants (Zeolite beads and silica gel) in the following ratio 1:0.5, 1:1, 1:2, 1:3 (Seeds: Beads) in air tight containers and kept at room temperature for Standardizing ultra seed drying. The Treatments details are given in the table (Table: 1).

Initial moisture content of seeds (10.5%) was estimated by hot air oven method. Seeds were separated from desiccant and estimated for moisture content after 24h, 48h, 72h, 96h and 120h of drying. Moisture content of the seeds was noted down at every 24h interval. At the end of the experiment, final moisture content of dried seeds was estimated.

Recharging zeolite beads and silica gel at 200°C for 2h

Seeds with silica gel and zeolite Beads

Fig 1: Mixing of Okra var. kashi Kranti seeds with desiccants

Table 1: Treatments details of Standardisation of Ultra dry storage of Okra var. Kashi Kranti seeds with Zeolite beads and silica gel

Treatments	Ratio Of Seeds: Desiccants	Duration
T1	1:0.5 (Seeds: Zeolite beads)	0 – 120h
T2	1:1 (Seeds: Zeolite beads)	0 – 120h
T3	1:2 (Seeds: Zeolite beads)	0 – 120h
T4	1:3 (Seeds: Zeolite beads)	0 – 120h
T5	1:0.5 (Seeds: Silica gel)	0 – 120h
T6	1:1 (Seeds: Silica gel)	0 – 120h
T7	1:2 (Seeds: Silica gel)	0 – 120h
T8	1:3 (Seeds: Silica gel)	0 – 120h
T_0	Control	0 – 120h

Data Analysis

The experiment was conducted with 8 treatments in 4 Replications. The experimental design used was CRD (Completely Randomized Design). The procured data was analysed using ANOVA technique (Analysis of Variance

Results and Discussion

At the end of the experiment, final moisture content of dried seeds was estimated. It was observed that seed drying with zeolite beads was faster than silica gel. Significantly higher moisture content was removed from seeds by zeolite beads, and final moisture content of seeds dried with zeolite beads reached 4.587% in 1:3 ratio, which was 35.5% higher moisture elimination than seeds dried with silica gel in the same ratio. The total moisture loss percentage for the eight treatments after 120h of drying with zeolite beads and silica gel are given in the following, T1-3.70% , T2- 4.28%, T3 - 5.28%, T4 - 5.91%, T5 – 2.45%, T6 – 3.36%, T7- 4.03%, T8- 4.29%, T_0 - 0.10%. The final moisture percentage after 120h of drying will be as following, T1- 6.80%, T2-6.22%, T3- 5.22%, T4- 4.59%, T5- 8.05%, T6-7.14%, T7-6.47%, T8- 6.21%, T9-10.50% (Table: 2). Gradual increase in weight of desiccants indicates continuous removal of moisture from the seeds during drying period.

Table 2: Total moisture (%) loss and final moisture content (%) after 120h of seed drying with desiccants

Treatments	Total moisture loss (%)	Final moisture (%) of dried seeds
T1	3.70	6.80
T2	4.28	6.22
T3	5.28	5.22
T4	5.91	4.59
T5	2.45	8.05
T6	3.36	7.14
T7	4.03	6.47
T8	4.29	6.21
Control	0.10	10.50
F test	S	
CD (0.05)	TxD	
	0.122	
CV (%)	6.87	

Initial moisture content observed: 10.5%

Table 3: Effect of desiccants on moisture loss (%) of okra cv. Kashi Kranti seeds

Treatment	Moisture (%) loss during different drying duration (without replacing desiccants)					
	D1 (0-24h)	D2 (25-48h)	D3 (49-72h)	D4 (73-96h)	D5 (97-120h)	Mean
T1	2.698d	0.456ijk	0.355klmn	0.118qrst	0.07t	0.739d
T2	2.852c	0.544i	0.436ijkl	0.282nop	0.164pqrst	0.856c
T3	3.107b	0.883gh	0.764h	0.304mno	0.221opqr	1.056b
T4	3.286a	0.963g	0.927g	0.418jklm	0.319lmn	1.183a
T5	1.956f	0.214opqrs	0.118qrst	0.098st	0.064t	0.490f
T6	2.458e	0.281nop	0.269nop	0.245nop	0.105qrst	0.672e
T7	2.668d	0.414jklm	0.436jkl	0.300mno	0.209nopqr	0.805c
T8	2.715d	0.497j	0.486j	0.349klm	0.239nop	0.857c
Mean	2.717a	0.532b	0.474c	0.264d	0.174e	
MSS	Treatment (df=39)	1.955				
	Error (df=40)	0.011				
F test	S					
CD (0.05)	T	D	TxD			
	0.054	0.043	0.122			
CV (%)	6.87					

Initial moisture content observed: 10.5%

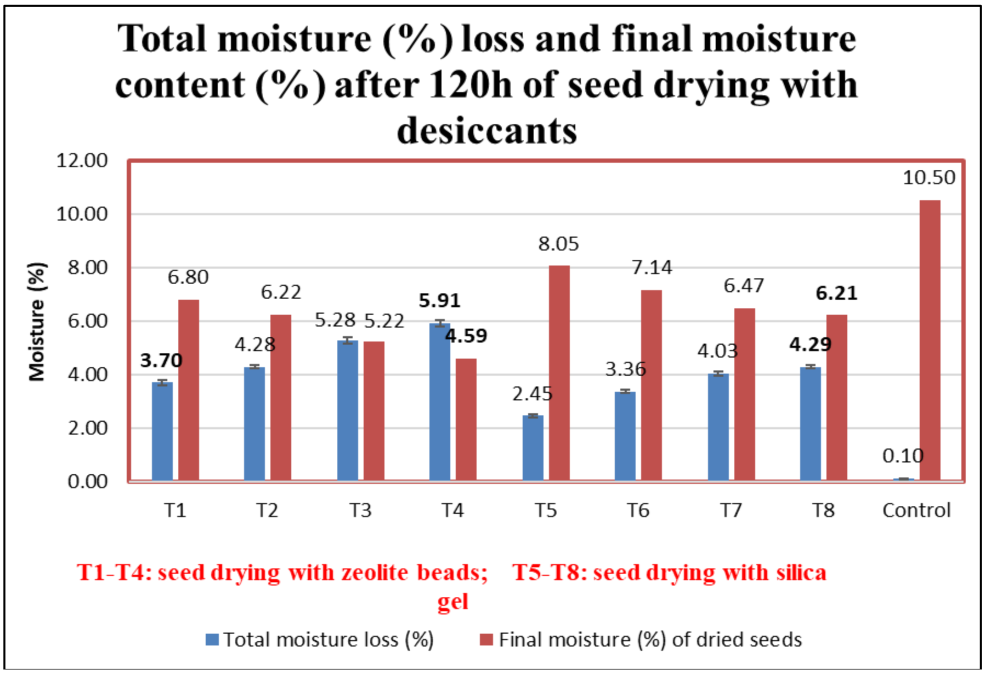

Fig 2: Total moisture (%) loss and final moisture content (%) after 120h of seed drying with desiccants

Data pertaining from the table, effect of desiccants on moisture loss (%) was found to be significant on okra cv. Kashi kranti seeds. The initial moisture content observed was 10.5%. The mean performance of the moisture loss% of all treatments during 0-24h of drying (D1) - 2.717%, 25-48h of drying (D2) - 0.532%, 49-72h of drying (D3) -0.474%, 73-96h of drying (D4) - 0.264%, 97-120h of drying (D5) - 0.174% was observed. The higher moisture content was removed from seeds (3.286%) within 24h by zeolite beads in T4 - 1:3 ratios. Significantly highest moisture content (5.91%)

was removed from seeds by zeolite beads in T4 - 1:3 ratio after 120h of drying. The lowest moisture content removed from seeds (0.10%) even after 120 h of drying was found in T_0 (control). The higher moisture content removed by silica gel (2.715%) in first 24 h was found in T8 - 1:3 ratio, which less than that of drying with zeolite beads. The total moisture loss after 120 h of drying by silica gel (4.29%) was observed in T8 - 1:3 ratio. (Table. 3)(Fig.2)

Final moisture content of seeds dried with zeolite beads reached 4.59% in T4 - 1:3 ratio after 120h of drying, which showed 35.5% higher moisture elimination than seeds dried with silica gel (6.21%) in the same ratio (T8 – 1:3). In all the treatments, maximum moisture content from seeds was removed within first 24h of drying. (Table. 2)

Since, hard seed formation is a problem in over dried okra seeds, germination test were conducted to know the germination (%) and vigour of dried seeds. Germination test reveals no reduction in germination (%) and no hard seed formation even in 1:3 ratio of seeds with zeolite beads. More than 80% germination was observed in all drying conditions and non-dried control which was on par with each other's. Thus, the effect of seed drying desiccants was nonsignificant with the seed quality parameters of okra cv. Kashi kranti seeds (Table: 4).

Table 4: Effect of seed drying with desiccants on seed quality of Okra cv. Kashi Kranti

Treatments	Germination (%)	Shoot length (cm)	Root length (cm)	seedling length (cm)	seedling fresh weight (mg/seedling)	seedling dry weight (mg/seedling)	Vigour index I	Vigour index II
T1	85 (67.19)	19	10	29	26.7	21.83	2465	1856
T2	83 (65.62)	16.8	11.6	28.47	27.9	22.73	2363	1887
T3	84 (66.40)	18	11	29	28.2	23	2436	1932
T4	86 (68.00)	21	9	30	29.6	23.3	2580	2004
T5	85 (67.19)	16.4	10.8	27.28	26.4	21.03	2319	1790
T6	83 (65.62)	17.5	11.2	28.73	28.1	22.03	2385	1830
T7	84 (66.40)	17.6	10.9	28.53	28.5	23	2397	1932
T8	85 (67.19)	18.6	10.9	29.5	28.3	23.4	2508	1989
Control	83(65.62)	17.6	10.9	28.52	29.5	23.27	2673	1931
Grand mean	84.4(66.76)	18.1	10.7	28.78	28.3	22.62	2464.52	1910.62
F test	NS	NS	NS	NS	NS	NS	NS	NS
CD (0.05)	3.57	2.03	2.17	2.22	3.51	1.46	415.02	157.39
CD (0.01)	4.9	3.08	3.11	3.04	4.9	1.99	568.7	215.67
CV (%)	2.47	4.3	4.1	4.49	5.53	3.75	9.82	4.80

In the this study, zeolite (beads) desiccant dried the seeds very rapidly than silica gel due to their microscopic pores form of alumina silicate minerals and has strong hydrophilic capacity to absorb and hold water very tightly in their micro pores. The moisture percent level of safe storage of vegetables stands 4 – 6%. Hence farmers, seed growers and seed industries of vegetable seeds can dry seeds using zeolite beads rapidly i.e. within a period of 24 hours under varied situations as compared to other desiccants to obtain minimum 3.70% moisture loss. As a result, the seeds could be stored for longer period without losing viability and vigour. More than that, the farmers of colder regions can dry their seeds independent of sun light and temperature. This ultra seed drying can also be utilized for germplasm conservation for longer storage. Further work is necessary to know the storability of ultra-dried seeds under air tight condition.

Conclusion

According to Harrington's Thumb Rule of seed storage, decrease in one percent (1%) moisture content will leads to double the life of seeds. Thus, lower the moisture content higher and safer the seed storage of vegetable seeds. The hard seed formation is more in *Malvaceae* family crops. By drying of those crops using this technology, may leads to prevent hard seed formation. By experimenting ultra seed drying using zeolite beads, it is concluded that rapid seed drying possible even upto 4% within 120h in 1:3 ratio of seeds: desiccants. This technology found to be more efficient and rapid compare to other seed drying technology. The quality and vigour of seeds also maintained the same even after ultra seed drying.

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