POST HARVEST DRYING OF TOMATO (*Lycopersicon esculentum* Mill) SEEDS TO ULTRA LOW MOISTURE SAFE FOR STORAGE USING DESICCANT (ZEOLITE) BEADS AND THEIR EFFECTS ON SEED QUALITY

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Abstract

An investigation was conducted on post harvest drying of tomato (Lycopersicon esculentum) seeds to safe storage moisture using desiccant (zeolite) beads and their effects on seed quality was carried out during August 2011 to April 2012 at the Department of Seed Science and Technology, ANGRAU, Rajendranagar, Hyderabad. The treatments included seed drying using zeolite beads and silica gel under ambient conditions. The experiment was laid out in completely randomized design with five treatments and three replications. The study revealed that zeolite beads at 1:1and 0.5:1 bead seed ratio dried the seeds to the lowest moisture content of 4.4 and 7% respectively after 96 hours of seed drying which was followed by silica gel at 1:1 and 0.5:1 silica gel to seed ratio which lowered seed moisture to 7.2% and 8.4% after 96 hrs of seed drying, respectively. Germination percent was not significantly (P=0.05) affected by the extent and speed of seed drying after 96 hrs with desiccants zeolite beads and silica gel and remained the same as that of the control.

Keywords: Tomato seeds; drying; Desiccant; Zeolite beads; moisture, storage;

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Introduction

Seed quality depends on factors like source, time and techniques of harvesting, processing including drying and storage practices. Special techniques are required for collection, handling, processing and storage of the seeds. Generally seeds are dried under the sun, if the crop is harvested during rainy season or under cloudy atmosphere it is very difficult to dry the seed. In such climates, high temperature and humidity combine to cause rapid deterioration of seeds under ambient conditions of storage resulting in poor quality seeds, poor stand establishment, lower productivity and disincentive to invest in improved seeds. Seed longevity is reduced by approximately half for every 1 per cent increase in seed moisture content (water content as per cent of fresh weight) or 5°C increase in temperature and the effects are additive [1]. This principle implies that seed storage life can be enhanced considerably by lowering both moisture and temperature. However, moisture content is the key factor that can be lowered for successful seed storage in tropical countries. Cold storage is expensive and difficult to maintain because the electricity supplies are often inconsistent and unreliable. In addition, seeds that are dried to low moisture contents are more tolerant of storage at warm temperatures. However, even prolonged sun drying in high humidities cannot reduce seed moisture content to the levels low enough to assure long-term viability**.**

Seeds are generally harvested at high moisture content and need to be dried before storage and to accomplish this, attention should be paid to the rate and extent of artificial post-harvest drying. If drying is too slow, there is a possibility of reduction in seed quality during the drying process due to seed ageing. On the other hand, if seeds are dried rapidly, a larger proportion may be lost due to desiccation damage [2] and there is no fixed rule that applies to all species. Delay in drying or slow drying together with high temperature (above 25°C) will tend to reduce viability considerably in orthodox seeds. The recommended methods for safe seed drying to a very low moisture content using seed drying chambers, seed dryers, where the relative humidity of the drying environment is controlled [3] may not be easily implemented in the seed industry due to the high cost of establishing, running and maintaining. Therefore, there is a need for low cost drying methods to be used as alternatives to such expensive seed drying equipments in order to lower the moisture content and to maintain safe moisture level suitable for seed storage to suit all the situations i.e. from individual farmers to seed industry. As an alternative desiccant drying technology, seed drying beads are modified ceramic materials (aluminum silicates or "zeolites") that specifically absorb and hold water molecules very tightly in their microscopic pores. The beads will continue to absorb water until all of their pores are filled, up to 20% of their initial weight. When placed in an enclosed space like a plastic or metal container, the beads will remove water from the air, creating and maintaining a very low humidity environment. Seeds placed into a container with the beads will lose water due to the low air humidity, and will continue to do so until they come to equilibrium. Hence, desiccant-based drying simply transfers the water in the seed to the drying beads through the air without the need for heating. Beads can be enclosed in a porous bag or container within the hermetic container with the seeds for convenience in separation. The beads can subsequently be removed and regenerated separately by heating at >200°C in an oven for 2 hours to release the absorbed water. Hence the study will investigate the extent and speed of drying tomato seeds using desiccant beads under ambient conditions to ultra low moisture content.

2. Material and Methods

The freshly harvested seeds of tomato cv. Arka vikas were collected from Agricultural Research Institute, Dr. Y.S.R Horticultural University, Rajendranagar, Hyderabad. The seeds were cleaned and sun dried at the temperature of 24^{o}C and relative humidity of 80% and used in the present study.

2.1 Determination of the extent and speed of drying using desiccant (zeolite) beads under ambient condition

Seeds with moisture content (MC) of 17% were used to determine the extent and speed of drying using desiccant beads under ambient condition, the following are treatments involved;

T_1: Sun drying (Control)
T_2: Air tight container + zeolite beads (1:1 bead seed ratio)
T_3: Air tight container + silica gel (1:1 silica gel seed ratio)
T_4: Air tight container + zeolite beads (0.5:1 bead seed ratio)
T_5: Air tight container + silica gel (0.5:1 silica gel seed ratio)

2.2. Method of drying

Tomato seeds were sundried by spreading in a thin layer on ground at a temperature ranging from 24 to 29^{o}C and a relative humidity of about 80% (Appendix 1) for ninety six hours (96hrs), with duration of 6 hours in a day.

Seeds with 17% MC were dried using zeolite beads and silica gel at 1:1 and 0.5:1 zeolite beads/silica gel to seed ratio in hermetic containers (Airtight plastic containers) for ninety six hours (96hrs) (Plate 1). Seeds were placed in a container with the beads and water loss from seeds was due to the low air humidity, and they continued to do so until they came to equilibrium. Hence, desiccant-based drying simply transfer the water in the seed to the drying beads through the air without the need of heating. Prior the beads was activated by heating at >200°C in an oven for 2 hours to release absorbed water from atmosphere (Plate 2). Silica gel is a spherical bead consisting of 97 to 100% of silica measuring 3-5mm, self indicating translucent bead impregnated with blue color. In this experiment 100 g tomato seeds were used in each treatment with three replications and were kept for 96 hours. The seed samples were drawn quickly from each of the treatments everyday to minimize the water absorption by beads from air for testing moisture content. At the end of the experiment i.e., after ninety six hours (96hrs), germination test was conducted for all the treatments. The containers were kept under ambient conditions. The following seed quality parameters were recorded in this experiment by adopting the standard procedures as detailed below.

2.3 Moisture content (%)

Moisture content of the seed was determined as per ISTA rules [4]. Five grams of seed was weighed and put in aluminium cups. The seed material kept in aluminium cups were dried in hot air oven maintained at $130 \pm 1^{o}C$ temperature for one hour.
The moisture content was determined on dry weight basis by using the following formula;

Moisture content (%) = $(W_2-W_3/W_2-W_1) \times 100$

Where, W_1 - Weight of empty container with its cover (g)
W_2 - Weight of container with its cover and seeds before drying (g)
W_3 - Weight of container with its cover and seeds after drying (g)

Plate 1: Seeds dried with beads in moisture proof container.

Plate 2: Activation of zeolite beads.

2.4 Germination percentage

Germination test was conducted on pure seed fraction using 100 seeds in four replicates following top paper method at 25^{0}C temperature and 90$\pm$3 per cent relative humidity [4]. The germinated seeds were evaluated into normal, abnormal seedlings and dead seeds on 14th day. The germination per cent was calculated based on the number of normal seedlings produced and expressed in percentage.

2.5: Data analysis

The experiment was laid out in Completely Randomized Design (CRD) replicated thrice, and the data obtained were analysed by using Analysis of Variance (ANOVA) technique (Gomez and Gomez 1984). Standard error of difference was calculated for each treatment effect and critical difference (CD) was calculated at 5 percent probability level to compare the mean difference among the treatments.

3. Results and Discussion

3.1 The extent and speed of drying using desiccant beads under ambient condition.

Biological activities occur only when moisture is present. Seeds absorb water from the ambient air when they are stored in humid environment and lose water when stored in low relative humidity. Therefore, moisture content (MC) of the seed as well as the moisture content of the surrounding air is important for safe storage. Generally, the MC of seeds harvested at harvest maturity is high and for processing it should be brought around 15-18% and for safe seed storage to 6-13% [5]. Lowering seed moisture content to safe level may be achieved by drying under sun, shade or artificial drying methods depending upon the kind of seed, facilities and situations but, each method have their advantages and limitations. The seed quality is greatly influenced by method of drying and rate of drying. Generally drying at high temperature, high relative humidity and uneven drying of seeds lowers the viability and vigour of seeds due to differential rate of loosing moisture content [6].

On the other hand, conventional drying i.e. sun drying, in which the temperature varied between 24 and 29^{o}C with a relative humidity of 80 per cent, which cannot dry seeds below safe storage level of MC even after drying for ninety six hours (96hrs), due to high temperature and high relative humidity. Therefore, drying method is crucial operation after harvest to reduce the moisture content of the seeds to a safe level of storage and maintenance throughout the storage period.

Tomato seeds contain high moisture of 60% to 70% at harvest and have to be dried to 9% [7]. In practice, various traditional and mechanical drying methods are used. With increase in tomato cultivation on commercial scale continuous and adequate supply of quality seed assumes greater importance and the post-harvest operations like seed drying and storage deserve due attention. Therefore, sooner the seed is extracted, cleaned and dried better will be the quality. The rate at which seed will give out this moisture is determined by how fast moisture migrates from the interior to the surface of the seed and by the speed at which the surface moisture is released to the surrounding air. If evaporation from the seed surface occurs too rapidly, the resulting moisture stress can damage the embryo and therefore seed should be dried carefully to arrest stress damage due to heat [8]. In contrast, if moisture elimination takes place too slowly, it may favour invasion of pathogens [9].

In the current study, zeolite (bead) desiccant dried the seeds very rapidly due to their micro pores form of alumina silicate minerals and has strong affinity specifically to absorb and hold water very tightly in their microscopic pores. Hence farmers, seed growers and seed industries can dry seeds using zeolite beads rapidly i.e. within a period of 48 hours under varied situations as compared to other desiccants. As a result, the seeds could be stored for longer period without loosing viability and vigour. Further, the current study also indicated that rapid drying of seeds will not have any deleterious effect on seed germination.

Removal of moisture was found to be very fast in desiccant drying using zeolite beads at ratio of (1:1 and 0.5:1) compared to sun drying (control) under ambient conditions. Zeolite beads at 1:1 bead to seed ratio lowered the seeds moisture from 17% to 5.6% within 24 hours and as lower as 4.4% after 96 hours, followed by zeolite beads at ratio of 0.5:1 which lowered seed moisture from 17% to 7.6% within 24 hours and after 96 hours recorded 7.0% seed moisture content (Figure 1, Table1).

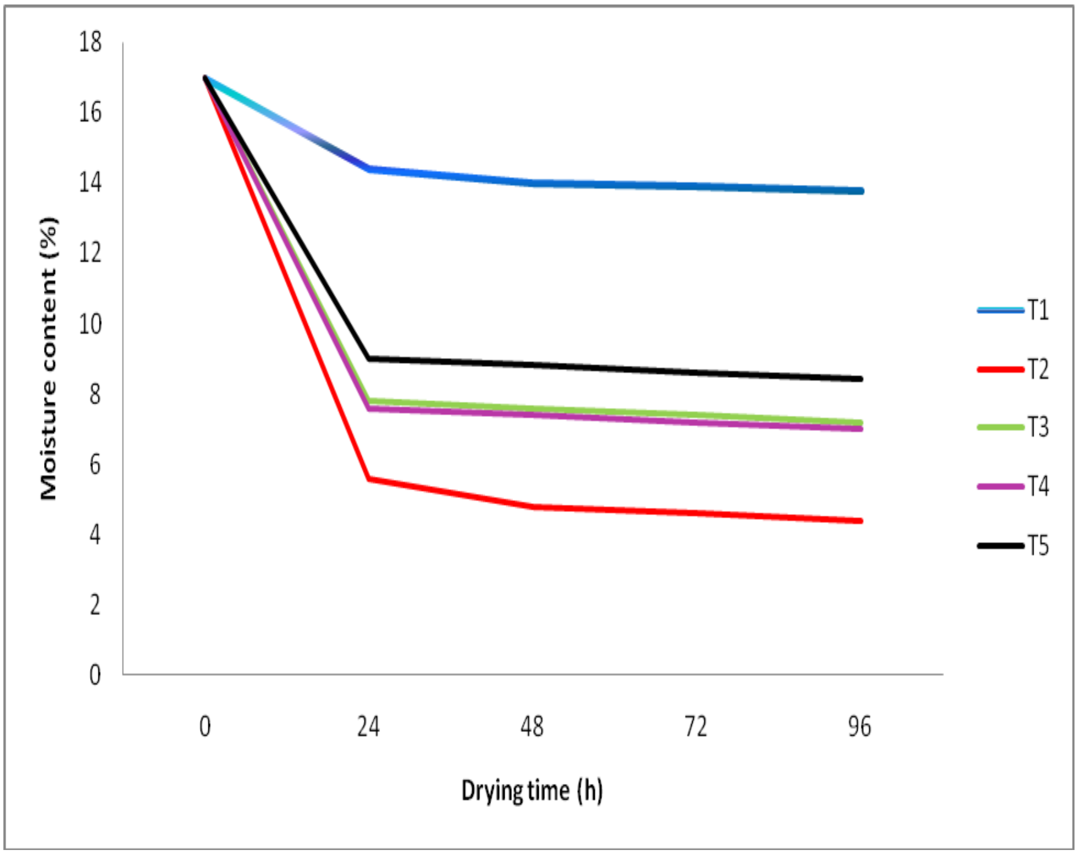

Fig. 1. Effect of drying methods on extent and speed of seed drying on moisture content and germination per cent of tomato seed

Key: $\mathbf{T_1}$: Sun drying (control), $\mathbf{T_2}$: Airtight container + Zeolite beads 1:1, $\mathbf{T_3}$: Air tight container + silica gel (1:1), $\mathbf{T_4}$**:** Airtight container + zeolite beads (0.5:1)**,** $\mathbf{T_5}$: Airtight container + silica gel (0.5:1)

Table 1. Effect of drying methods on extent and speed of seed drying on moisture content and germination per cent of tomato seed

Treatments	Moisture content (%)					Germination (%)	
	0 h	24 h	48 h	72 h	96 h	0 h	96 h
T_1: Sun drying (control)	17 (24.35)	14.4 (22.30)	14.0 (22.00)	13.9 (21.92)	13.8 (21.78)	96	96 (78)
T_2: Airtight container + zeolite beads (1:1)	17 (24.35)	5.6 (13.69)	4.8 (12.66)	4.6 (12.38)	4.4 (12.11)	96	96 (78)
T_3: Airtight container + silica gel (1:1)	17 (24.35)	7.8 (16.22)	7.6 (16.0)	7.4 (15.78)	7.2 (15.56)	96	96 (78)
T_4: Airtight container + zeolite beads (0.5:1)	17 (24.35)	7.6 (16.0)	7.4 (15.78)	7.2 (15.56)	7.0 (15.34)	96	96 (78)
T_5: Airtight container + silica gel (0.5:1)	17 (24.35)	9 (17.46)	8.8 (17.26)	8.6 (17.1)	8.4 (16.85)	96	95 (77)
SEm	8.07	5.39	5.99	6.09	0.062	0.00	0.291
CD at 5%	2.54	0.170	0.189	0.192	0.194	0.00	NS

The results from the present study in respect of desiccant seed ratio suggested that 1:1 desiccant seed ratio is better to bring down to ultra dry storage conditions thereby seed viability and vigour can be extended for a long period. Similar results were reported by [10] they dried *asparagus* bean seeds from 12 to 4 per cent using silica gel with a ratio of 4:1 silica gel: seed. Also [11] dried rice seeds using silica gel at the ratio of (1:1) to 5 percent moisture content. [12] dried bean seeds from 14 to 5 per cent MC for 30-34 days at the ratio of 1:2 silica gel seed ratio. Seed germination was not significantly affected by desiccant drying in both ratios for four days, same results was reported by [13] in drying soybean with silica gel to seed ratio of 3:1, 2:1 and 1:1.

4. Conclusion

High seed moisture is more injurious to seed as increases the metabolism and favors the growth of microorganism at higher temperature especially in tropics, where tomato is grown. In the present study, the zeolite desiccant beads at 1:1 and 0.5:1 bead to seed ratio were more effective in tomato seed drying to ultra low moisture level for storage in air tight container even at higher relative humidity and higher temperature followed by silica gel without seed quality reduction, hence suitable technology to small scale farmers and seed companies to store precious seed material for a longer period.

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APPENDIX – I

Mean monthly meteorological data for experimental year (August 2011 to April 2012) of main Agricultural Research Station, Rajendranagar Hyderabad.

Months	Rainfall (mm)	Temperature ^{0}C		Relative Humidity (%)
		Mean max.	Mean min.	
August 2011	147.3	30.2	22.7	80.5
September 2011	68.1	30.7	22	81
October 2011	47.9	32.1	20.3	79.5
November 2011	27.5	30.1	15.4	63.5
December 2011	-	29.9	12.6	61.5
January 2012	-	30.1	14.2	57
February 2012	-	33	15.4	49.2
March 2012	-	36.9	17.3	41.5
April 2012	30.8	37.5	22.6	51.5