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EFFECT OF ZEOLITE BEADS (DESICCANT BEADS) ON TOMATO SEED STORABILITY AND SEED QUALITY

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ABSTRACT

High temperature and humidity combine to cause rapid seed deterioration of seeds under ambient conditions of storage, causing poor quality seeds hence poor productivity in Agricultural crop production. An investigation was conducted whether seed drying using desiccants (zeolite beads) and airtight packaging would prevent or ameliorate these consequences of storage.

The laboratory experiment was laid out in completely randomized design with three replications and five treatments which include storage of seeds using airtight container, airtight container with silica gel (1:1), airtight container with zeolite beads (1:1), poly pouches and cloth bag as control. The difference in moisture content was statistically significant for all the treatments. Seed dried and stored with zeolite desiccant beads showed lowest moisture (2.1%) after 6 months of storage and slightly changed to 2.3% after 8 months of storage, followed by silica gel (5.2%), cloth bag (9.6%), poly pouch (13.3%) and airtight container (13.5%) after eight months of storage period. The seedling vigour index I varied significantly among the treatments.

ISSN: 2455-6939

Volume: 10, Issue: 02 "March-April 2024"

Seed stored with desiccant silica gel showed the highest vigour index I (1747), followed by zeolite beads (1728) compared to cloth bag (1277) at the end of storage period. Seed dried and stored with desiccants silica gel showed the lowest electrical conductivity (0.289 dSm^{-1}) followed by zeolite beads (0.293 dSm^{-1}), compared to cloth bag (0.421 dSm^{-1}) at 8th month of storage. The results demonstrate the superior ability of desiccants to quickly and safely dry seeds prior to and during storage and the benefits of such drying and storing seeds in air tight container to preventing seed deterioration during seed storage under ambient conditions.

Keywords: Zeolite beads, Seed storability, Seed quality, Desiccant drying, Silica gel, Moisture content

1. INTRODUCTION

Tomato (*Lycoperscon esculentum L.*) is one of the most important vegetables grown widely throughout the world because of its wider adaptability, high yielding potential and suitability to different agro climatic conditions. Tomato is India's most extensively grown vegetable crop after potato (*Solanum tuberosum* L.). It is cultivated over an area of 0.789 million hectares with a production of 78.9 million tonnes and productivity of 25 t ha^{-1}[16]. With the increasing population of India at the rate of 1.2 per cent annually, which may cross the population of China by the middle of the century thus, the demand of tomato in our country is increasing day by day. Therefore, there is a need to increase the production and productivity levels to feed the increasing population and to meet food processing industry requirements viz., juice, ketchup, sauces, chutney etc. In addition, we can earn a considerable amount of foreign exchange through exports. Tomato production and productivity is influenced by various factors including availability of good quality seed.

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 [15]. 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 [6] 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 [7] 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 equipment in order to lower the moisture content and to maintain safe moisture level during storage to suit all the situations i.e. from individual farmers to seed industry. Seed drying with desiccants is not a novel technology, desiccants such as wood ash, rice grains, alumina, molecular sieve, calcium chloride and silica gel have been used to dry seeds, though some are inefficient to dry the seeds to the desired moisture content and others works only at a certain relative humidity. Specific drying equipment based upon silica gel is available. However, silica gel has less affinity for water than seed drying beads at low humidities to the dry the seeds to optimal storage moisture contents. Silica gel can be regenerated by heating at relatively low temperature, there is loss of water-holding capacity with each cycle of regeneration and it must eventually be replaced. As an alternative desiccant drying technology, drying (zeolite) beads which are made of modified ceramic materials (aluminum silicates) that specifically absorb water molecules and can be used as an effective and low-cost drying method (WWW.drying beads.com). Storing seeds inside the containers with the drying beads will remove water from the seeds and dry them without heating.

2.0 MATERIAL AND METHODS

2.1 Determination of the effect of zeolite beads (desiccant beads) on seed storability and seed quality

The bead and silica gel seed ratio of 1:1(150g of tomato seed: 150g of zeolite beads and silica gel) was used in this experiment to dry and store the seeds at ultra dry conditions at Telangana State Agricultural University- Hyderabad. The experiment was laid out in Completely Randomized Design with five treatments and three replications each. All the observations were recorded in each replication and the mean value was considered for statistical analysis. The details of the experiment is given below

T_1: Seed stored in cloth bag (Control)

ISSN: 2455-6939

Volume: 10, Issue: 02 "March-April 2024"

T_2: Seed stored in air tight container

T_3: Seed stored in air tight container + Silica gel (1: 1 silica gel seed ratio)

T_4: Seed stored in air tight container + Zeolite beads (1: 1 zeolite bead seed ratio)

T_5: Seed stored in poly pouch (700 gauge)

2.2 Method of storage

Four hundred and fifty grams of tomato seeds were taken for each treatment and kept in three replications of 150g each and were placed in cloth bag (control), poly pouch, air tight container, air tight container with silica gel and air tight container with zeolite beads. The containers were kept under ambient conditions during storage. Observations were recorded periodically for every two months for a period of eight months, from August 2010 to April 2011 for seed quality parameters.

2.3 Collection of Experimental Data

2.3.1 Moisture content (%)

Moisture content of the seed was determined as per ISTA rules [11]. 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.

$$\text{Moisture content (\%)} = (W_2\text{-}W_3/W_2\text{-}W_1) \text{ X } 100$$

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)

2.3.2 Germination (%)

Germination test was conducted on pure seed fraction using 100 seeds in four replicates following top paper method at 25^{0}Ctemperature and 90$\pm$3 per cent relative humidity [11]. 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.

2.3.3 Seedling Vigour Index-1(SVI-1)

ISSN: 2455-6939

Volume: 10, Issue: 02 "March-April 2024"

The vigour indices were calculated by adopting the method suggested by [1] and were expressed as whole number.

Seedling Vigour Index I (SVI-I) = Germination (%) x Seedling length (cm)

2.3.4 Electrical conductivity (dSm-1)

Five grams of seeds in three replications were soaked in acetone for half a minute and thoroughly washed in distilled water for five times. Then the seeds were soaked in 25 ml distilled water and kept in an incubator maintained at 25^0 C for 24 hours. The seed leachate was collected and volume was made up to 25 ml by adding distilled water. The electrical conductivity of the seed leachate was measured in an electrical conductivity bridge (ELICO) with a cell constant of 1.0 and the mean values were expressed in deci Siemens per meter [14].

2.3.5 Field emergence (%)

Twenty five seeds in four replications were taken randomly for each treatment and hand dibbled in well prepared raised seed bed. Seeds were sown equidistantly and watered to maintain the optimum soil moisture for emergence. The number of normal seedlings emerged three centimeters above the soil surface on 15^{th} day after sowing were counted and expressed as field emergence in percentage [14].

2.3.6 Statistical analysis

The experiments were laid out in Completely Randomized Design (CRD) replicated thrice and the data obtained were analysed by using Analysis of Variance (ANOVA) technique [9]. 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.

3.0 RESULTS AND DISCUSSION

The seed with initial moisture content at 12.9 percent at the beginning of the seed storage, desiccants had a remarkable effect on seed moisture content and maintenance of seed viability and vigour for eight months of seed storage.

Seeds stored in airtight container with silica gel and airtight container with zeolite beads observed the lowest moisture content throughout the storage period in the present study. Silica gel reduced the moisture content from 12.9 to 5.2 per cent, whereas zeolite beads reduced seed moisture content from 12.9 to 2.5 per cent. (Figure 1) this may be due to highly polar surface within the pores which is main driving force for moisture adsorption from the seeds, similar

ISSN: 2455-6939

Volume: 10, Issue: 02 "March-April 2024"

results on zeolite beads was reported by [19] who dried and stored brinjal seeds in airtight container with zeolite beads, zeolite beads lowered moisture content from 8 to 3.8 percent. In the present study, seeds stored with airtight container and poly pouch although they were impervious to moisture content change and varied slightly with storage time from 12.9% to 13.5% and 13.3% respectively, this can be due to seed respiration and moisture contamination during sampling for collection of data, same results were reported by [21] in okra seed which were stored under ambient conditions in poly pouch where the fluctuation of moisture content was from 9.10% to 10.57%.

In the present study, seeds stored in cloth bag (control), moisture per cent fluctuated with environmental conditions, i.e. seed moisture content was higher (12.7%) at higher relative humidity (80.5%) and temperature (26^0C) during rainy season and was as low as 9.6% during summer. As a result, the seed moisture changed depending on the relative humidity and temperature in order to equilibrate with atmospheric moisture. The change in seed moisture during storage in cloth bag might be the reason responsible for faster seed deterioration through its effect on cell membrane, the loss of structural integrity of membrane upon dehydration of seeds and its retention affect viability of seeds. High moisture content of 14.7 percent for wheat seeds stored using earthen pot (farmers practise) after nine month of seed storage was observed by [13], also [3] observed high moisture content of soya bean stored using cloth bag which fluctuate from 8.3 to 15.01 percentage after sixty days of storage.

Moisture content is the key factor for successful seed storage. In the current study, moisture content lowered with zeolite beads at ultra drying level i.e., below 3.6 per cent for 8 months and maintained the germination above seed certification standards.

Elevated relative humidity and temperature during storage not only cause seed deterioration, but also make seeds more prone to insect and fungal attack [4]. Some studies have confirmed that low moisture content storage can not only be used to maintain the quality of seeds, but also improve their storability [18]. The longevity of tomato seeds could be extended further by reducing atmospheric humidity [22]. Similarly, in *Ammopiplanthusmangolica* seed could be stored at ambient temperature (25ºC) with relatively low moisture content and their longevity decreased as seed moisture content increased [25]. In the current study, when tomato seeds were dried to a moisture content of 5.2% and 2.1% with silica gel and zeolite beads respectively, the germination per cent was not statistically influenced and ageing of seeds is minimized at ultra dry storage.

ISSN: 2455-6939
Volume: 10, Issue: 02 "March-April 2024"

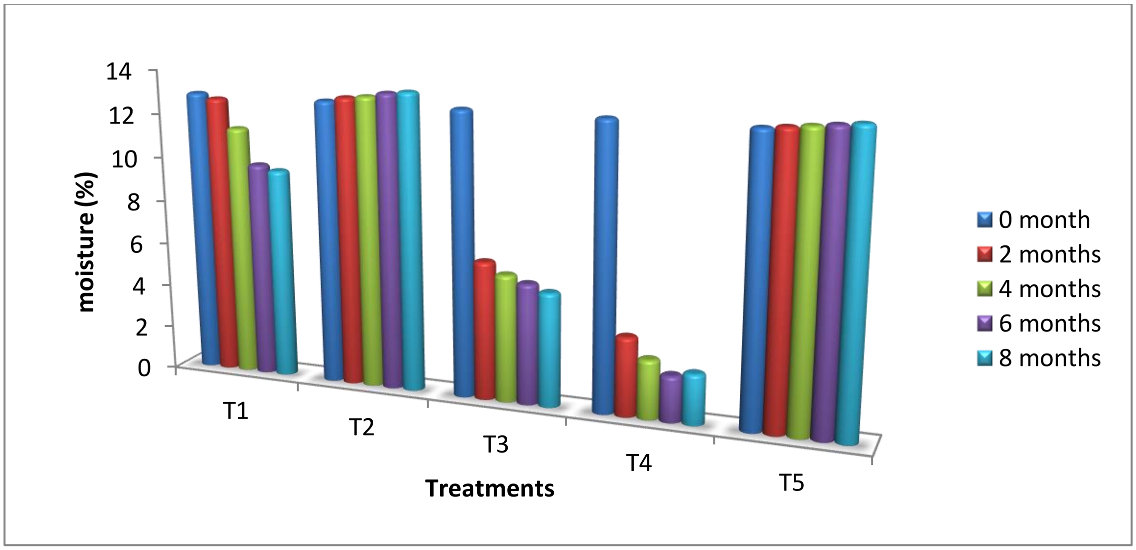

Figure 1: Effect of desiccants on moisture content of tomato seeds during storage

T_1: Sun drying (control)

T_2: Airtight container + Zeolite beads 1:1

T_3: Air tight container + silica gel (1:1)

T_4: Airtight container + zeolite beads (0.5:1)

T_5: Airtight container + silica gel (0.5:1)

The loss of germinability and vigour of seed during storage is inevitable. These losses occur in storage due to many factors such as moisture content, temperature, relative humidity, length of storage period and storage containers, Poor storage condition gives rise to deterioration of seed quality and the resultant loss of viability [2]. The present study revealed that the initial germination was 92% in tomato seeds. A significant effect on seed germination percentages was observed using desiccants, poly pouch and airtight container (Figure 2.) Seed packed in airtight container with desiccants such as silica gel and zeolite beads maintained high germination percentage throughout the storage period and found higher germination percentages of 89% and 88% respectively, compared to other treatments (T_1,T_2 and T_5) at the end of storage period, and the retention of high seed viability might be due to lowering of seed moisture at ultra dry conditions i.e., by silica gel and zeolite beads during storage which resulted to low seed respiration and maintenance of cell membrane. This point is an important one, as [2] tomato and onion seeds demonstrated significantly high vigour germination percentage of ranger 71-78% and 68-74 % respectively after drying and storage. Also [12] found that onion seed maintained viability of 81% after dried and stored using zeolite beads in airtight container for 15 months. Viability of seed stored with cloth bag decreased gradually with advancement of storage period

ISSN: 2455-6939

Volume: 10, Issue: 02 "March-April 2024"

and this might be due to free passage of air as a result seed might absorb the water from ambient air creating congenial conditions for growth of micro organisms.

However, all the treatments maintained high germination per cent i.e. above seed certification standards except the seed stored in cloth bag. This is mainly because of higher and fluctuating moisture content during storage period. This is in accordance with the findings of [10] reported lowest germination of 65 percentage of cowpea seeds stored in cotton bags for 90 days.

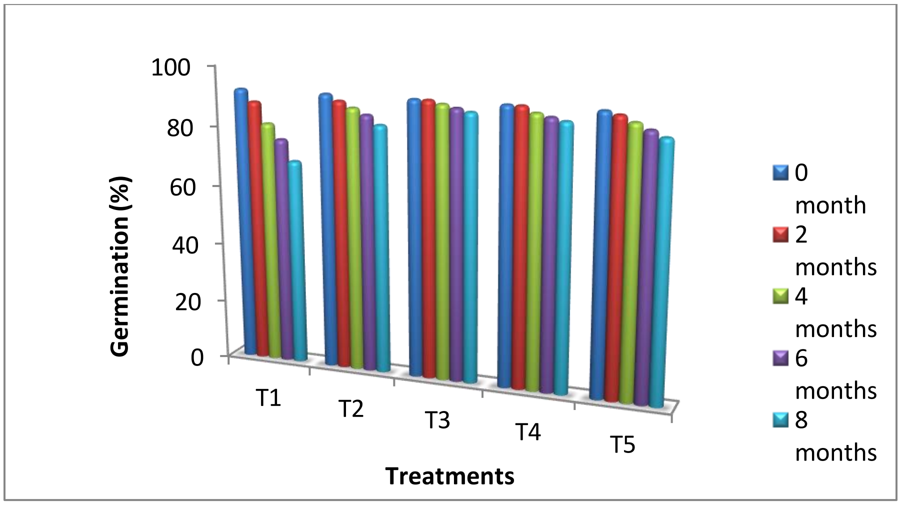

Figure 2: Effect of desiccants on germination percentage of tomato seeds during storage

T_1: Sun drying (control) T_2: Airtight container + Zeolite beads 1:1

T_3: Air tight container + silica gel (1:1) T_4: Airtight container + zeolite beads (0.5:1)

T_5: Airtight container + silica gel (0.5:1)

Seedling vigour is an important parameter in assessing seed quality. In the current study, seedling vigour as reflected in seedling length was higher in seeds stored in airtight container with silica gel and zeolite beads (T_3 and T_4) which recorded higher seedling vigour index I (Fig. 3) compared to cloth bag (T_1). The seeds stored with silica gel and zeolite beads maintained low moisture which might have resulted in lower respiration rate, lower metabolic activity and maintenance of higher seed vigour during storage. This lower moisture maintained in a airtight container might be responsible for higher germination, seedling length, seedling dry weight and seedling vigour index as a result greatly extending storage life as reported by[18] in Brinjal and chilli, Also [17] reported higher seedling vigour index of (1229)when soya bean seeds were stored in pearl pet jars with silica gel

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Volume: 10, Issue: 02 "March-April 2024"

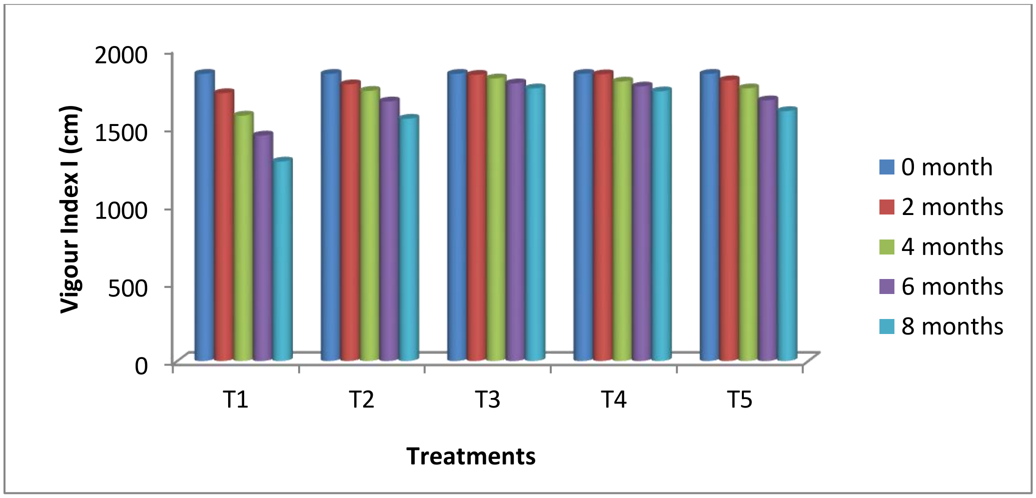

Figure 3: Effect of desiccants on Seedling Vigour Index I of tomato seeds during storage

T_1: Sun drying (control)

T_2: Airtight container + Zeolite beads 1:1

T_3: Air tight container + silica gel (1:1)

T_4: Airtight container + zeolite beads (0.5:1)

T_5: Airtight container + silica gel (0.5:1)

The electrical conductivity test measures the amount of electrolytes which leach from seed during imbibition is a sensitive index of seed quality which shows negative association with seed germination [5]. In the present study, the electrical conductivity of seed leachate is negatively correlated with the seed viability and vigour. Seeds stored with silica gel and zeolite beads (T_3 and T_4) recorded lower electrical conductivity compared to the seeds stored in cloth bag (T_1) (Figure 4), this is because of the influence of lower moisture maintained by desiccants silica gel and zeolite beads results of slow rate of lipid peroxidation, thereby release of minimum free radicals which lead to maintenance of membrane integrity, this results in slow leakage of intracellular substances (electrolytes and other solutes) which are responsible for maintenance of seed germination during storage. However, in cloth bag, air tight container and poly pouch showed significant increase in the electrical conductivity of seed leachate values during storage. This may be due to the increase in the percentage of dead and abnormal seeds at different periods of storage. Effect of seed ageing on electrolyte leakage have been reviewed by [23] reported that, seeds stored with effective desiccants (zeolite beads, activated alumina, sodium aluminum silicate, silica gel) consistently having significantly lower electrical conductivity values after 9 months of seed storage.

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Volume: 10, Issue: 02 "March-April 2024"

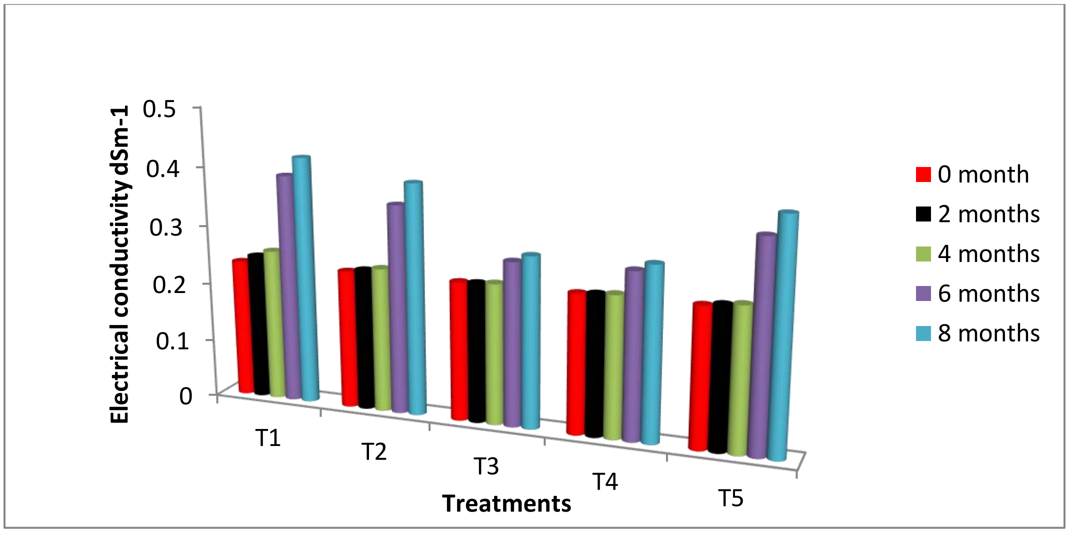

Figure 4: Effect of desiccants on Electrical conductivity of seed leachate of tomato seeds during storage

T_1: Sun drying (control)

T_2: Airtight container + Zeolite beads 1:1

T_3: Air tight container + silica gel (1:1)

T_4: Airtight container + zeolite beads (0.5:1)

T_5: Airtight container + silica gel (0.5:1)

Modern crop production systems require a high degree of precision in crop establishment. The need for high plant population densities and uniform plant stand requires seeds of high quality that constantly produce rapid and uniform seedlings from each seed sown. In the present study, seeds stored with zeolite beads took significantly less days to 50 per cent of emergence as compared to seed stored in cloth bag (T_1), poly pouch (T_5) and air tight container (T_2). However, seed stored with silica gel also exhibited early field emergence and was on par with zeolite beads (Figure 5). Therefore the seeds preserved in air tight container under dry conditions with silica gel and zeolite beads revealed higher seedling quality with respect to germination, vigour index, field emergence and lower electrical conductivity. These are in accordance with the findings of[24] who observed higher field emergence of 81% for rice seeds stored in airtight container with zeolite beads after 16 months of seed storage also [8] observed higher field emergence of 75% for soybean seeds dried to safer moisture content and stored in impervious poly-line jute canvas compared to previous jute canvas (71%) after one year of storage.

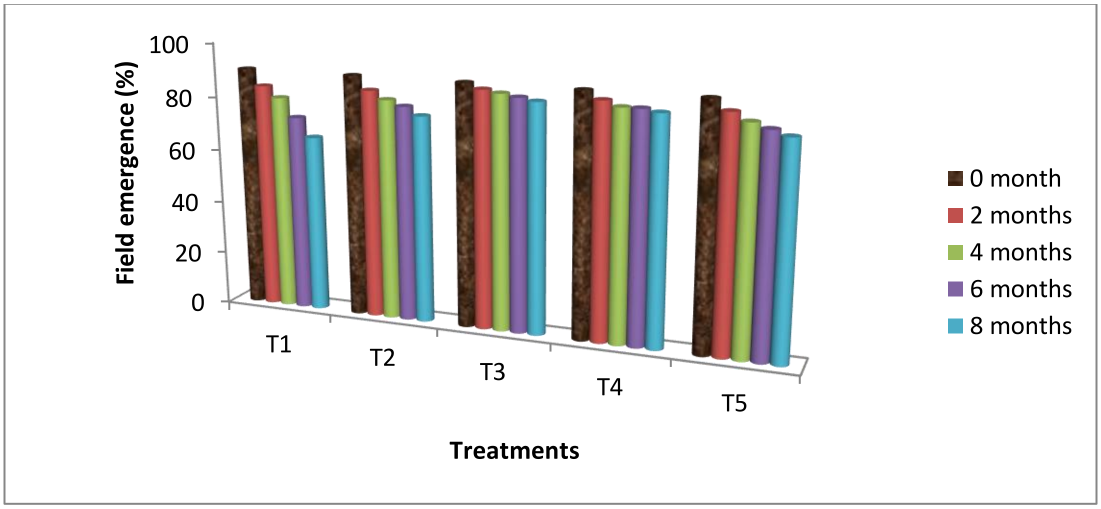

Figure 5: Effect of desiccants on Field emergence percent of tomato seeds during storage

T_1: Sun drying (control)

T_2: Airtight container + Zeolite beads 1:1

T_3: Air tight container + silica gel (1:1)

T_4: Airtight container + zeolite beads (0.5:1)

T_5: Airtight container + silica gel (0.5:1)

4.0 CONCLUSION

In the present study, the zeolite desiccant beads were more effective in tomato seed drying to ultra-low moisture level in air tight container even at higher relative humidity and higher temperature. Secondly, it was established that though silica gel recorded higher for certain seed quality traits for a period of 8 months, the zeolite beads showed results which was on par with silica gel and maintained higher seedling characteristics but it could extend the storage life for a long period with a minimal loss of seed viability, vigour and maintenance of seed health. Desiccant seed drying using zeolite beads and silica gel to ultra-low moisture content in airtight container is a feasible technology to small scale farmers and gene bank for longer storage of precious seed materials.

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