Impact of Various Desiccants on Seed Quality parameters in Okra (*Abelmoschus esculentus* L. Moench)

ABSTRACT

A laboratory experiment was conducted at the Department of Seed Science and Technology, University of Agricultural Sciences, GKVK, Bangalore, Karnataka. The study aimed to investigate the impact of various desiccants on seed quality parameters in okra (*Abelmoschus esculentus* L. Moench) along with the comparison of untreated control. The findings indicated that zeolite beads (1:0.2 seed: desiccant by weight) for 24 h. registered significantly lowest (8.04 %) seed moisture content and lowest (349.18 µS/cm) electrical conductivity as compared to the control (12.10 % and 356.35 µS/cm/g, respectively). Similarly, zeolite beads (1:0.2 seed: desiccant by weight) for 24 h. registered the highest (76.85 %) seed germination, root length (16.56 cm), shoot length (14.02 cm), mean seedling dry weight (98.03 mg), seedling vigour index-I (2303), seedling vigour index-II (7542) and highest (2.38 A_{480nm}) total dehydrogenase activity indicating better seed quality as compare to control (70.27 %, 12.57 cm, 10.28 cm, 91.82 mg, 1623, 6461 and 1.80 $A_{480nm,}$ respectively). Overall, the results suggest that zeolite beads are an effective desiccant for enhancing seed quality in okra by reducing moisture content and improving physiological and biochemical parameters, which are critical for seed storage and vigor.

Keywords: Desiccants; Super grain bag; Zeolite beads

1. INTRODUCTION

Okra (*Abelmoschus esculentus* L. Moench), commonly referred to as Ladies finger or "Bhendi", holds significant agricultural importance as a key vegetable crop cultivated across the country during both rainy and dry seasons. It is native of tropical Africa. Out of 34 species of Abelmoschus only the species *Abelmoschus esculentus* is known to be cultivated extensively as commercial vegetable. It is grown in India throughout the period for its young fruits as vegetable, both as garden and commercial farms.

In India, okra is cultivated on an area of 554,000 hectares, with a production of 72,88,000 metric tons and productivity rate of 13.14 metric tons per hectare (Anon., 2023). The major okra-producing states in India include Uttar Pradesh, Bihar, West Bengal, Odisha, Assam, Andhra Pradesh and Karnataka. Karnataka, in particular, is enriched with diverse agroclimatic conditions, allowing farmers to cultivate a wide diverse range of crops is grown year-round, including grains, legumes and oil-bearing plants, commercial crops and horticultural crops across different seasons. In Karnataka, okra is grown on 2.82 thousand hectares, with a production of 41.97 metric tons and a productivity rate of 14.91 metric tons per hectare (Anon., 2023).

Hard seed formation is a common problem in over-dried okra seeds. Sun drying is traditionally used to dry seeds, but it is challenging to reduce seed moisture due to high humidity and fluctuating temperatures. Moreover, sun drying is labor-intensive and time-consuming, potentially causing adverse effects on seed quality. Desiccant drying offers an alternative. Desiccants like zeolite beads (aluminum silicate) and silica gel can be used for ultra-drying seeds. Other desiccants such as bentonite and salts like calcium sulfate, calcium chloride and sodium chloride has also been effectively used to reduce seed moisture content, as demonstrated by studies. However, desiccant drying is generally a slow process. While some desiccants like silica gel can be regenerated by heating and repeated heating causes a loss of water-holding capacity due to polymerization. This makes it a less viable option for prolonged usage. Recently, zeolite beads have emerged as a more efficient desiccant for seed drying (Nivethitha *et al.*, 2020). Zeolite beads have a greater tendency to bind with water than silica gel even at low humidity levels. Furthermore, unlike silica gel, zeolite beads do not lose their water-holding capacity after repeated regeneration processes for making them a superior and more sustainable option for seed drying.

2. MATERIALS AND METHODS

In this experiment, freshly harvested seeds from five genotypes of *Abelmoschus esculentus* were used. The seeds were stored using Super Grain Bags as the packaging material. These bags were selected based on their capability to maintain low oxygen levels and stable humidity, which are vital for safeguarding seed viability, vigor and germination potential over extended periods. The experiment was carried out using a factorial design with a completely randomized layout with 5 genotypes, 5 treatments, three replications and total of 75 (5× 5 ×3) treatment combinations *i.e.*

Factor I: Genotypes (G): G_1: NOK-16 **G_2:** NOK-21 **G_3:** NOK-26

G_4: NOK-28 **G_5:** NOK-29

Factor II: Treatments (T): T_1: Zeolite beads (1:0.2 Seed: Desiccant by weight) for 24 hours

T_2: Silica gel (1:0.1 Seed: Desiccant by weight) for 72 hours

T_3: Silica gel (1:0.3 Seed: Desiccant by weight) for 48 hours

T_4: Silica gel (1:0.5 Seed: Desiccant by weight) for 24 hours

T_5: Control

The study was conducted at the Department of Seed Science and Technology, UAS, GKVK, Bangalore. Various seed quality parameters were assessed, including seed moisture content (%), seed germination rate (%), root length (cm), shoot length (cm), mean seedling dry weight (mg), seedling vigor indices, electrical conductivity ($\mu S cm^{-1} g^{-1}$) and total dehydrogenase activity (A_{480nm}).

Seed moisture (%): Moisture content of the seeds was assessed by the hot air oven method by grinding 5 gm okra seeds in grinding mill and dried at 130 ^{o}C for 2 hours in hot air oven. The percentage of seed moisture was determined on the wet weight basis.

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

Where,

M_1 = Weight of the container with lid

M_2 = Weight of the container with lid + seed before drying

M_3 = Weight of the container with lid + seed after drying

Seed germination (%): The standard germination test was carried out by following between paper method as per ISTA procedure (Anon., 2021). Hundred seeds in four replications were taken from each treatment and placed on germination paper uniformly. The roll towels were kept in a germination chamber maintained at 25 ± 2 °C temperature and 90 ± 5 per cent relative humidity. The first count was taken on 4th day and final count on 21st day. The count of normal seedlings from each replication was recorded, and the average germination was presented as a percentage.

$$\text{Seed germination (\%)} = \frac{\text{Number of normal seedlings}}{\text{Total number of seeds used for the test}} \times 100$$

Root length (cm)

From the germination test, ten normal seedlings were selected randomly from each treatment from all the replications on 21st day. The root length was measured from the tip of the primary root to base of hypocotyl and mean root length was expressed in centimeter.

Shoot length (cm)

From the germination test, ten normal seedlings were selected randomly from each treatment from all replications on 21st day. The shoot length was measured from the base of the primary leaf to the base of the hypocotyl and mean shoot length was expressed in centimetre.

Mean seedling dry weight (mg)

From the germination test the same ten seedlings used for measuring the root and shoot length were kept in a butter paper packet and dried in hot air oven maintained at 80° ± 2°C for 24 hours. Then the seedlings were cooled in a desiccator for 30 minutes and the weight of the dry seedlings was recorded using electronic balance and was expressed in milligrams / 10 seedlings.

Seedling vigour indices (SVI)

The seedling vigour index- I and II were calculated by employing the formula given by Abdul-Baki and Anderson (1973).

SVI -I was calculated by using the following formula:

SVI -I = Germination (%) x [Root length (cm)+Shoot length (cm)]

SVI II was calculated by using the following formula:

SVI-II = Germination (%) x Mean seedling dry weight (mg)

Electrical conductivity of the seed leachate ($\mu Scm^{-1}g^{-1}$)

Twenty-five seeds of three replications were taken randomly from each treatment in a beaker. Then the seeds were soaked in 25 ml of distilled water for 24 hr. at 25 ± 1^{o}C. The steeped water from soaked seeds was collected and the electrical conductivity (EC) of seed leachate was measured in digital conductivity meter (Model: Systronic conductivity meter

306). After subtracting the EC of the distilled water from the value obtained from the seed leachate, the actual EC due to electrolyte was measured and expressed in ($\mu Scm^{-1}g^{-1}$).

Total dehydrogenase activity (A_{480nm})

The total dehydrogenase activity of the seeds was estimated as per the method described by Perl *et al*. (1978). 25 seeds of each replications selected randomly are pre-conditioned by soaking in water for 24 hours. Seeds of each treatment were dehusked and immersed in 1 percent tetrazolium chloride solution in test tubes and incubated for 12 hours in dark. Then they were washed thoroughly with distilled water, the red coloured formazan from the stained seeds is extracted by soaking these seeds with 5 ml of 2-methoxyethanol for 6-8 hours in an airtight container. The extract is decanted and the colour intensity is measured in spectrophotometer at 480 nm with suitable blank (2-Methoxy ethanol). The total dehydrogenase activity (TDH) was expressed in OD value.

3. RESULTS AND DISCUSSION

The findings of the study on the effects of different desiccants on seed quality parameters in okra (*Abelmoschus esculentus* L. Moench) are shown in Table 1-5 and Fig. 1-2.

A significant variation was observed in seed moisture percentage among the genotypes. The genotype NOK-21 (G_2) recorded the lowest (8.95 %) seed moisture percentage followed by NOK-16 (9.09 %) and the highest (9.53 %) was registered in NOK-28 (G_4). The seed moisture content varied significantly with the different desiccants. The zeolite beads (1:0.2 seed: desiccant by weight) for 24 h. (T_1) registered the lowest (8.04 %) seed moisture which was followed by silica gel (1:0.3 seed: desiccant by weight) for 48 h. (8.25 %) and the highest (12.10 %) was recorded in control (T_5). The interaction between genotypes and desiccants did not significantly affect seed moisture content. However, the lowest seed moisture percentage (7.79 %) was observed with zeolite beads (1:0.2 seed: desiccant by weight) for 24 h. in NOK-21 (T_1G_2), followed by (T_1G_1) (7.84 %) in NOK-16 under the same treatment. The highest moisture content (12.57 %) was recorded in control for NOK-28 (T_5G_4).

This effect can be ascribed to the use of zeolite bead desiccants, which facilitate rapid seed drying due to their microporous structure composed of aluminosilicate minerals. These desiccants exhibit a strong affinity for water, effectively absorbing and retaining moisture within their microscopic pores. Consequently, the seeds can be kept for prolonged periods without compromising viability or vigour. Furthermore, the findings of the current study align with those of Nassari *et al.* (2014), indicating that rapid seed drying does not have a detrimental impact on germination of tomato.

Significant difference for seed germination percentage was observed among the genotypes. The genotype NOK- 21 (G_2) recorded highest (80.60 %) seed germination which is followed by NOK-16 (76.82 %) and lowest (70.36 %) was registered in NOK-28 (G_4).

The seed germination percentage differed significantly with the different desiccants. The zeolite beads (1:0.2 seed: desiccant by weight) for 24 h. (T_1) registered the highest (76.85 %) seed germination percentage followed by (76.08 %) in silica gel (1:0.3 seed: desiccant by weight) for 48 h. (T_3) and lowest (70.27 %) was found in control (T_5). The interaction between genotypes and desiccants showed non significant difference for seed germination percentage. However, the highest germination (83.00 %) was recorded with zeolite beads (1:0.2) for 24 h. in NOK-21 (T_1G_2), followed by T_3G_2 (82.00 %) with silica gel (1:0.3) for 48 h. in NOK-21, while the lowest (66.00 %) was observed in control for NOK-28 (T_5G_4).

Among the genotypes, significant difference was observed for root length. The genotype NOK- 21 (G_2) recorded highest (19.23 cm) root length which is followed by (16.78 cm) in NOK-16 (G_1) and lowest (11.73 cm) was registered in NOK-28 (G_4). The root length differed significantly with the different desiccants. The zeolite beads (1:0.2 seed: desiccant by weight) for 24 h. (T_1) registered the highest (16.56 cm) root length followed by (15.82 cm) in silica gel (1:0.3 seed: desiccant by weight) for 48 h. (T_3) and lowest (12.57 cm) was found in control (T_5). The interaction between genotypes and desiccants showed significant difference for root length. The highest root length (20.25 cm) was observed with zeolite beads (1:0.2) for 24 h. in NOK-21 (T_1G_2), followed by (20.11 cm) with silica gel (1:0.3) for 48 h. in NOK-21 (T_3G_2). The lowest root length (9.33 cm) was recorded in the control for NOK-28 (T_5G_4).

Significant difference was noticed for shoot length among the genotypes. The genotype NOK- 21 (G_2) recorded highest (14.10 cm) shoot length which is followed by G_1 (13.41 cm) NOK-16 and lowest (10.19 cm) was registered in NOK-28 (G_4). The shoot length differed

Table 1. Effect of different desiccants on seed moisture percentage of okra genotypes

Treatments	Seed moisture (%)

	G_1	G_2	G_3	G_4	G_5	Mean
T_1	7.84	7.79	8.13	8.32	8.09	**8.04**
T_2	8.54	8.43	8.64	8.73	8.58	**8.59**
T_3	8.08	7.91	8.42	8.50	8.32	**8.25**
T_4	9.17	8.83	9.32	9.54	9.28	**9.23**
T_5	11.84	11.80	12.28	12.57	12.02	**12.10**
Mean	**9.09**	**8.95**	**9.36**	**9.53**	**9.26**	
	S.Em±	**CD (P=0.05)**	**CV (%)**			
G	**0.06**	**0.18**	**2.65**			
T	**0.06**	**0.18**				
TxG	**0.14**	**NS**				

Table 2. Effect of different desiccants on seed germination (%) of okra genotypes

Treatments	Seed germination (%)					
	G_1	G_2	G_3	G_4	G_5	Mean
T_1	78.85	83.00	73.67	73.40	75.32	**76.85**
T_2	77.56	81.63	72.74	70.61	74.88	**75.48**
T_3	78.75	82.00	73.00	71.73	74.93	**76.08**
T_4	76.57	79.92	71.88	70.08	73.52	**74.39**
T_5	72.36	76.45	66.08	66.00	70.45	**70.27**
Mean	**76.82**	**80.60**	**71.47**	**70.36**	**73.82**	
	S.Em±	**CD (P=0.05)**	**CV (%)**			
G	**0.70**	**1.98**	**3.62**			
T	**0.70**	**1.98**				
TxG	**1.56**	**NS**				

Legend

G: Genotypes- **G_1:** NOK-16 **G_2:** NOK-21 **G_3:** NOK-26 **G_4:** NOK-28 **G_5:** NOK-29

T: Treatments- **T_1:** Zeolite beads (1:0.2 Seed: Desiccant by weight) for 24 hrs.

T_2: Silica gel (1:0.1 Seed: Desiccant by weight) for 72 hrs.

T_3: Silica gel (1:0.3 Seed: Desiccant by weight) for 48 hrs

T_4: Silica gel (1:0.5 Seed: Desiccant by weight) for 24 hrs.

T_5: Control

Packaging material: Super grain bag

significantly with the different desiccants. The zeolite beads (1:0.2 seed: desiccant by weight) for 24 h. (T_1) registered the highest (14.02 cm) shoot length followed by (13.59 cm) in silica gel (1:0.3 seed: desiccant by weight) for 48 h. (T_3) and lowest (10.28 cm) was found in control (T_5).

The interaction between genotypes and desiccants showed significant difference for shoot length. The highest shoot length (15.20 cm) was observed with zeolite beads (1:0.2) for 24 h. in NOK-21 (T_1G_2), followed by (15.05 cm) with silica gel (1:0.3) for 48 h. in NOK-21 (T_3G_2). The lowest shoot length (8.20 cm) was recorded in the control for NOK-28 (T_5G_4).

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 Ninganna *et al.* (2018) in Brinjal and chilli and Nethra *et al.* (2016) reported higher seedling vigour index was obtained, when soya bean seeds were stored in pearl pet jars with silica gel.

Among the genotypes, significant difference was observed for mean seedling dry weight. The genotype NOK- 21 (G_2) recorded highest (98.34 mg) mean seedling dry weight which is followed by (97.59 mg) in NOK-16 (G_1) and the lowest (90.82 mg) was registered in NOK-28 (G_4). Significant difference was observed for mean seedling dry weight among the different desiccants. The zeolite beads (1:0.2 seed: desiccant by weight) for 24 h. (T_1) registered the highest (98.03 mg) mean seedling dry weight followed by (96.51 mg) in silica gel (1:0.3 seed: desiccant by weight) for 48 h. (T_3) and lowest (91.82 mg) was found in control (T_5). The interaction between genotypes and desiccants showed significant difference for mean seedling dry weight. The highest mean seedling dry weight (101.04 mg) was with zeolite beads (1:0.2) for 24 h in NOK-21 (T_1G_2), followed by (99.80 mg) in NOK-16 (T_1G_1) under the same treatment. The lowest (88.62 mg) was recorded in the control for NOK-28 (T_5G_4).

The increase in dry weight might be due to Zeolites have ion-exchange properties that help to retain and release nutrients slowly, benefiting root and shoot development. They can adsorb and gradually release beneficial ions like potassium, which promotes cell expansion and elongation in developing seedlings, supporting greater seedling length (Basavarajappa *et al.*, 2022) and these desiccants minimize oxidative stress by absorbing moisture and stabilizing the

Table 3. Effect of different desiccants on root and shoot length (cm) of okra genotypes

Treatments	Root length (cm)						Shoot length (cm)					
	G_1	G_2	G_3	G_4	G_5	**Mean**	G_1	G_2	G_3	G_4	G_5	**Mean**
T_1	18.75	20.25	14.88	13.25	15.67	**16.56**	14.81	15.20	13.63	12.45	14.00	**14.02**
T_2	16.73	19.71	13.90	12.00	13.33	**15.13**	13.94	14.83	12.81	10.33	13.17	**13.02**
T_3	17.32	20.11	14.15	12.80	14.72	**15.82**	14.53	15.05	13.17	11.33	13.85	**13.59**
T_4	16.11	19.00	12.71	11.28	13.12	**14.44**	12.73	13.25	12.31	8.64	12.64	**11.91**
T_5	15.00	17.10	10.33	9.33	11.10	**12.57**	11.05	12.16	9.45	8.20	10.52	**10.28**
Mean	**16.78**	**19.23**	**13.19**	**11.73**	**13.59**		**13.41**	**14.10**	**12.27**	**10.19**	**12.84**	
	S.Em±	**CD (P=0.05)**	**CV (%)**				**S.Em±**	**CD (P=0.05)**	**CV (%)**			
G	**0.12**	**0.35**	**3.18**				**0.14**	**0.40**	**4.31**			
T	**0.12**	**0.35**					**0.14**	**0.40**				
TxG	**0.27**	**0.78**					**0.31**	**0.89**				

Legend

G: Genotypes- **G_1:** NOK-16 **G_2:** NOK-21 **G_3:** NOK-26 **G_4:** NOK-28 **G_5:** NOK-29

T: Treatments- **T_1:** Zeolite beads (1:0.2 Seed: Desiccant by weight) for 24 hrs. **T_2:** Silica gel (1:0.1 Seed: Desiccant by weight) for 72 hrs.

T_3: Silica gel (1:0.3 Seed: Desiccant by weight) for 48 hrs **T_4:** Silica gel (1:0.5 Seed: Desiccant by weight) for 24 hrs.

T_5: Control **Packaging material:** Super grain bag

Table 4. Effect of different desiccants on mean seedling dry weight (mg) of okra genotypes

Treatments	Mean seedling dry weight (mg)					
	G_1	**G_2**	**G_3**	**G_4**	**G_5**	**Mean**
T_1	99.80	101.04	95.22	94.80	99.29	**98.03**
T_2	98.11	98.62	92.98	89.21	97.42	**95.27**
T_3	99.60	99.32	93.28	91.52	98.83	**96.51**
T_4	95.71	97.37	90.12	89.98	94.33	**93.50**
T_5	94.73	95.34	89.67	88.62	90.75	**91.82**
Mean	**97.59**	**98.34**	**92.26**	**90.82**	**96.12**	
	S.Em±	**CD (P=0.05)**	**CV (%)**			
G	**0.32**	**0.91**	**1.31**			
T	**0.32**	**0.91**				
TxG	**0.72**	**2.04**				

Legend

G: Genotypes- **G_1:** NOK-16 **G_2:** NOK-21 **G_3:** NOK-26 **G_4:** NOK-28 **G_5:** NOK-29

T: Treatments- **T_1:** Zeolite beads (1:0.2 Seed: Desiccant by weight) for 24 hrs.

T_2: Silica gel (1:0.1 Seed: Desiccant by weight) for 72 hrs.

T_3: Silica gel (1:0.3 Seed: Desiccant by weight) for 48 hrs

T_4: Silica gel (1:0.5 Seed: Desiccant by weight) for 24 hrs.

T_5: Control

Packaging material: Super grain bag

storage environment, which prevents lipid peroxidation and protein denaturation that could otherwise impair seedling growth. Seeds stored under these stable conditions tend to have higher energy reserves, which contribute to greater biomass accumulation during seedling development (Milojevic-Rakic and Bajuk-Bogdanovic, 2023).

There is a significant difference was noticed for seedling vigour index-I among the genotypes. The genotype NOK- 21 (G_2) recorded highest (2583) seedling vigour index-I which is followed by NOK-16 (2262) and lowest (1535) was registered in NOK-28 (G_4). Significant difference was observed for seedling vigour index-I among the different desiccants. The zeolite beads (1:0.2 seed: desiccant by weight) for 24 h. (T_1) registered the highest (2303) seedling vigour index-I followed by (2197) in silica gel (1:0.3 seed: desiccant by weight) for 48 h. (T_3) and lowest (1623) was found in control (T_5). The interaction between genotypes and desiccants showed significant difference for seedling vigour index-I. The highest seedling vigour index-I (2768) was with zeolite beads (1:0.2) for 24 h. in NOK-21 (T_1G_2), followed by silica gel (1:0.3 seed: desiccant by weight) for 48 h. (2743) in NOK-21 (T_3G_2) and the lowest (1157) was recorded in the control for NOK-28 (T_5G_4).

Significant difference was observed for seedling vigour index-II among the genotypes. The genotype NOK- 21 (G_2) recorded highest (7930) seedling vigour index-II which is followed by (7500) in NOK-16 (G_1) and lowest (6396) was registered in NOK-28 (G_4). Significant difference was observed for seedling vigour index-II among the different desiccants. The zeolite beads (1:0.2 seed: desiccant by weight) for 24 h. (T_1) registered the highest (7542) seedling vigour index-II followed by (7353) in silica gel (1:0.3 seed: desiccant by weight) for 48 h. (T_3) and lowest (6461) was found in control (T_5). The interaction between genotypes and desiccants showed non significant difference for seedling vigour index-II. However, highest seedling vigour index-II (8387) was with zeolite beads (1:0.2) for 24 h. in NOK-21 (T_1G_2), followed by silica gel (1:0.3 seed: desiccant by weight) for 48 h. (8144) in NOK-21 (T_3G_2) and the lowest (5849) was recorded in the control for NOK-28 (T_5G_4).

There is a significant difference with respect to electrical conductivity among the genotypes. The genotype NOK-21 (G_2) recorded lowest (342.98 μS/cm/g) followed by (G_1)

NOK-16 (345.52 μS/cm/g) and highest (363.91 μS/cm/g) electrical conductivity registered in NOK- 28 (G_4).

Table 5. Effect of different desiccants on seedling vigour index-I and II of okra genotypes

Treatments	Seedling vigour index-I						Seedling vigour index-II					
	G_1	G_2	G_3	G_4	G_5	Mean	G_1	G_2	G_3	G_4	G_5	Mean
T_1	2573	2768	2110	1844	2220	**2303**	7869	8387	7015	6959	7478	**7542**
T_2	2328	2649	1929	1581	1953	**2088**	7606	8050	6764	6300	7295	**7203**
T_3	2440	2743	2014	1724	2061	**2197**	7843	8144	6809	6564	7405	**7353**
T_4	2101	2498	1744	1368	1849	**1912**	7328	7782	6478	6306	6935	**6966**
T_5	1868	2257	1307	1157	1524	**1623**	6855	7289	5925	5849	6387	**6461**
Mean	**2262**	**2583**	**1821**	**1535**	**1922**		**7500**	**7930**	**6598**	**6396**	**7100**	
	S.Em±	**CD (P=0.05)**	**CV (%)**				**S.Em±**	**CD (P=0.05)**	**CV (%)**			
G	**17.02**	**48.34**	**3.26**				**64.87**	**184.28**	**3.54**			
T	**17.02**	**48.34**					**64.87**	**184.28**				
TxG	**38.05**	**108.09**					**145.06**	**NS**				

Legend

G: Genotypes- **G_1:** NOK-16 **G_2:** NOK-21 **G_3:** NOK-26 **G_4:** NOK-28 **G_5:** NOK-29

T: Treatments- **T_1:** Zeolite beads (1:0.2 Seed: Desiccant by weight) for 24 hrs. **T_2:** Silica gel (1:0.1 Seed: Desiccant by weight) for 72 hrs.

T_3: Silica gel (1:0.3 Seed: Desiccant by weight) for 48 hrs **T_4:** Silica gel (1:0.5 Seed: Desiccant by weight) for 24 hrs.

T_5: Control **Packaging material:** Super grain bag

Significant difference was observed for electrical conductivity among the different desiccants. The zeolite beads (1:0.2 seed: desiccant by weight) for 24 h. (T_1) registered the lowest (349.18 μS/cm/g) electrical conductivity followed by (351.30 μS/cm/g) in silica gel (1:0.3 seed: desiccant by weight) for 48 h. (T_3) and highest (356.35 μS/cm/g) was found in control (T_5). The interaction between genotypes and desiccants showed non significant difference for electrical conductivity. However, the lowest value (339.15 μS/cm/g) was observed with zeolite beads (1:0.2) for 24 h in NOK-21 (T_1G_2), followed by NOK-16 (T_1G_1) at (340.45 μS/cm/g). The highest (366.91 μS/cm/g) was recorded in the control for NOK-28 (T_5G_4).

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 (Chen and Zhon, 1990). Seeds stored with silica gel and zeolite beads recorded lower electrical conductivity compared to the seeds stored in cloth bag, 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. Similar findings were reviewed by Sudha Rani *et al*. (2015) that, seeds stored with effective desiccants (zeolite beads, activated alumina, sodium aluminium silicate, silica gel) consistently having significantly lower electrical conductivity.

There is a significant difference for total dehydrogenase activity among the genotypes. The genotype NOK- 21 (G_2) recorded highest (2.27 A_{480}nm) total dehydrogenase activity which is followed by (2.22 A_{480}nm) in NOK-16 (G_1) and lowest (2.11 A_{480}nm) was registered in NOK-28 (G_4). The total dehydrogenase activity differed significantly with the different desiccants. The Zeolite beads (1:0.2 Seed: Desiccant by weight) for 24 h. (T_1) registered the highest (2.38 A_{480}nm) total dehydrogenase activity followed by (2.31 A_{480}nm) in Silica gel (1:0.3 Seed: Desiccant by weight) for 48 h. (T_3) and lowest (1.80 A_{480}nm) was found in control (T_5). The interaction between genotypes and desiccants showed non significant difference for total dehydrogenase activity. However, highest total dehydrogenase activity (2.45 A_{480}nm) was observed with zeolite beads (1:0.2) for 24 h. in NOK-21 (T_1G_2) which was on par with (2.40 A_{480}nm) in NOK-16 (T_1G_1) and the lowest total dehydrogenase activity (1.70 A_{480}nm) was recorded in the control for NOK-28 (T_5G_4).

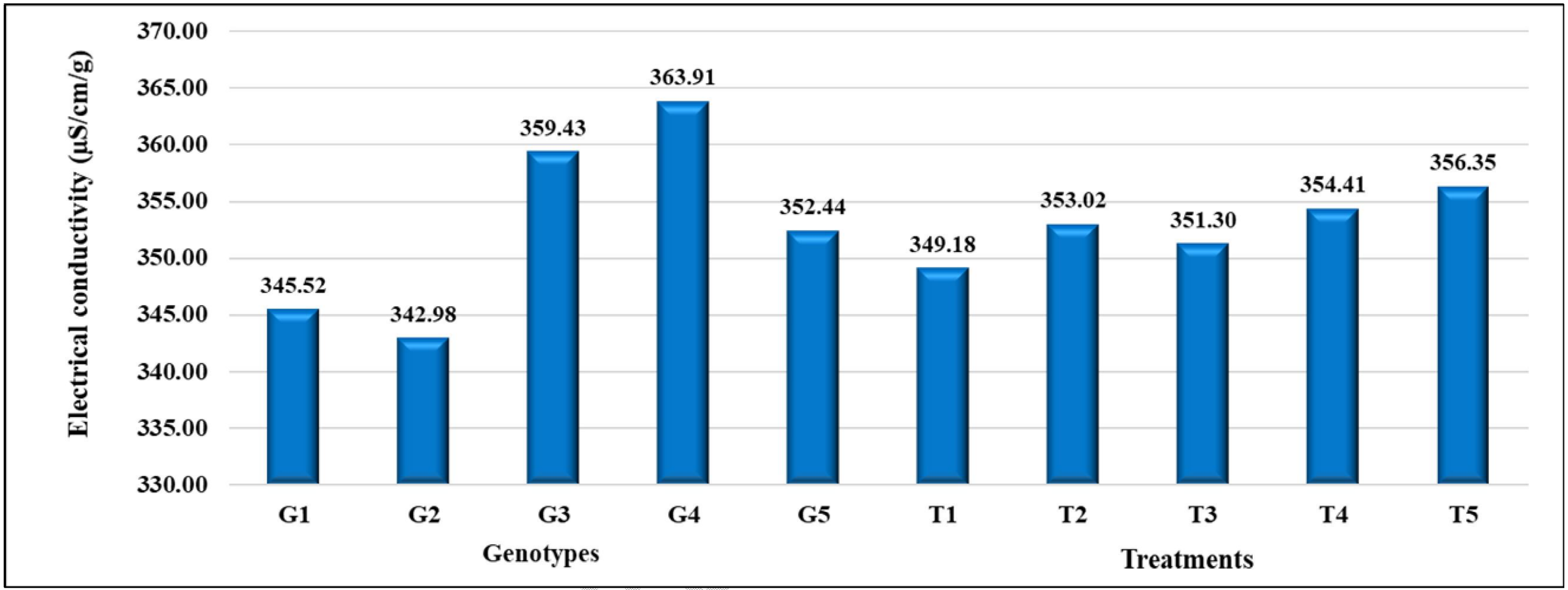

Fig. 1. Effect of different desiccants on electrical conductivity (µS/cm/g) of okra genotypes

Legend

G: Genotypes- **G_1:** NOK-16 **G_2:** NOK-21 **G_3:** NOK-26 **G_4:** NOK-28 **G_5:** NOK-29

T: Treatments- **T_1:** Zeolite beads (1:0.2 Seed: Desiccant by weight) for 24 hrs.

T_2: Silica gel (1:0.1 Seed: Desiccant by weight) for 72 hrs.

T_3: Silica gel (1:0.3 Seed: Desiccant by weight) for 48 hrs

T_4: Silica gel (1:0.5 Seed: Desiccant by weight) for 24 hrs.

T_5: Control

Packaging material: Super grain bag

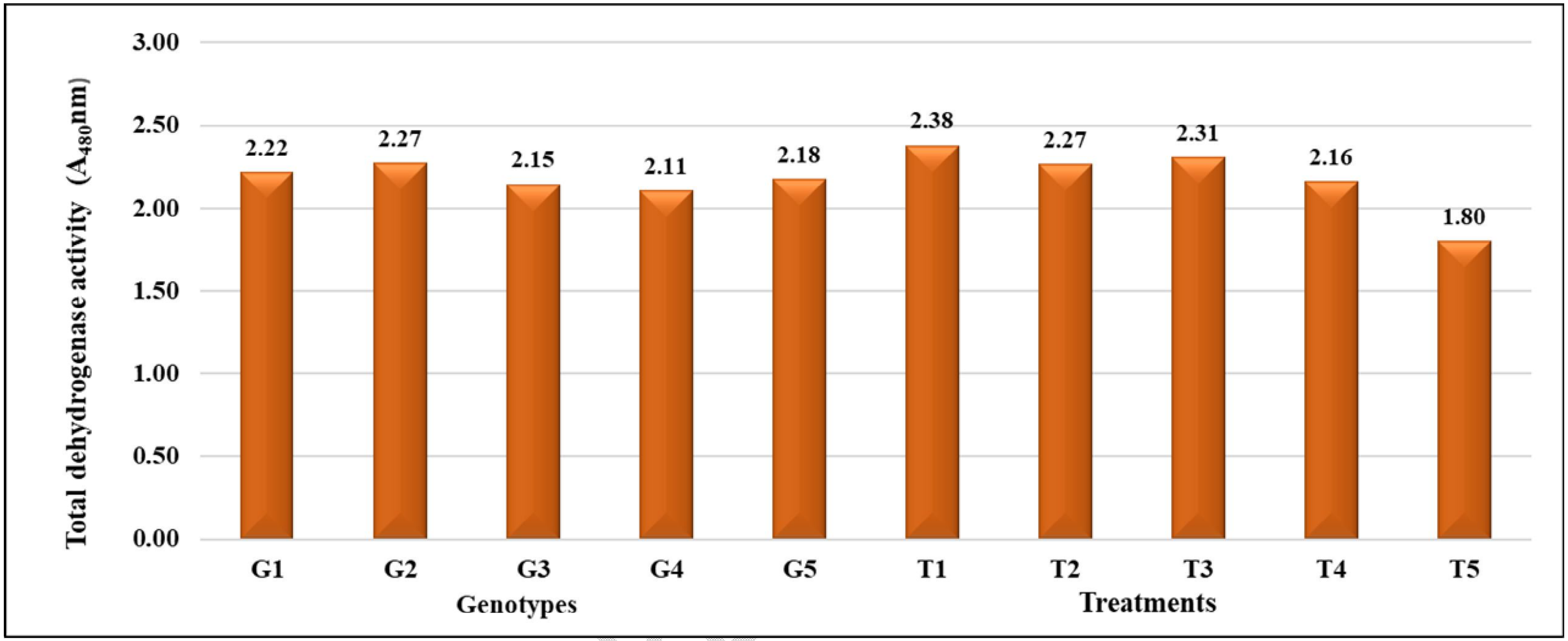

Fig. 2. Effect of different desiccants on total dehydrogenase activity (A_{480}nm) of okra genotypes

Legend

G: Genotypes- **G_1:** NOK-16 **G_2:** NOK-21 **G_3:** NOK-26 **G_4:** NOK-28 **G_5:** NOK-29

T: Treatments- **T_1:** Zeolite beads (1:0.2 Seed: Desiccant by weight) for 24 hrs.

T_2: Silica gel (1:0.1 Seed: Desiccant by weight) for 72 hrs.

T_3: Silica gel (1:0.3 Seed: Desiccant by weight) for 48 hrs

T_4: Silica gel (1:0.5 Seed: Desiccant by weight) for 24 hrs.

T_5: Control

Packaging material: Super grain bag

Zeolite beads creates low-humidity storage conditions, in which seeds experiences less biochemical deterioration. As a result, enzymes like dehydrogenases that are crucial for respiration and energy production remain stable, enabling seeds to have higher metabolic activity and dehydrogenase levels at the time of germination (Vertucci and Roos, 1990).

4. CONCLUSION

Zeolite beads effectively reduce relative humidity in seed storage environments by adsorbing water molecules, maintaining optimal moisture levels. By keeping moisture low, zeolite beads reduce the risk of mold, fungi and microbial activity, which can compromise seed

health and viability. In this study, zeolite beads, used at a 1:0.2 seed-to-desiccant ratio by weight for 24 hours, were identified as the most effective moisture absorbent for maintaining seed quality. Similarly, silica gel, applied at a 1:0.3 seed-to-desiccant ratio by weight for 48 hours, was observed to be the best overall desiccant. Proper moisture control, as achieved through these treatments, preserved the physiological integrity of the seeds and significantly improved seed quality.

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