Hindawi
Advances in Agriculture
Volume 2023, Article ID 3951752, 9 pages
https://doi.org/10.1155/2023/3951752

Research Article

Effect of Seed Priming Methods on Seed Quality of Okra (*Abelmoschus esculentus* (L.) Moench) Genotypes

Mekuria Bereded Sheferie

Department of Horticulture, College of Agriculture and Natural Resource, Salale University, P.O.B. 245, Salale, Fiche, Ethiopia

Correspondence should be addressed to Mekuria Bereded Sheferie; mekuriamb@gmail.com

Received 18 October 2022; Revised 11 January 2023; Accepted 13 January 2023; Published 27 January 2023

Academic Editor: Faheem Ahmed Khan

Seed priming is an effective way of promoting seed germination and vigor of okra by alleviating seed dormancy in fresh or stored okra seeds. An experiment was carried out to evaluate the effect of seed priming treatment on seed physiological quality of okra genotypes. This experiment was conducted in a laboratory at Haramaya University in a completely randomized design with 4 replications. It comprised of 5 seed priming treatments (untreated seeds, tape water, 200 ppm GA_3, 0.5% KH_2PO_4, and 50% cow urine) and 5 okra genotypes (Clemson, Arka Anamika, SOH701, 240207, and 240586). The results showed that the main and interaction effects of seed priming treatment and genotypes significantly affected physiological seed quality attributes and hard seed percentage. GA_3-treated genotype Clemson showed the highest germination (78.28%) and germination speed (25.29). Similarly, GA_3-treated genotypes SHO701 and 240586 had the highest seed vigor index I (13.161) and vigor index II (34.14), respectively. There were no hard seeds in genotype Clemson treated with GA_3 and cow urine, genotype SOH701 treated with GA_3, besides genotype 240207 treated with KH_2PO_4 and tap water. All seed priming treatments had a significant positive effect on physiological quality and seed overcame seed hardness in all 5 okra genotypes compared to controls. Therefore, in this study concluded that GA_3 seed priming treatment improved physiological seed quality, and alleviated seeds hardness in okra genotypes. As an alternative to GA_3 seed priming treatments, Ethiopian farmers can also use tape water, cow urine, and KH_2PO_4 seed priming treatments.

1. Introduction

Okra (*Abelmoschus esculentus* (L.) Moench) is one of the most commonly used species in the Malvaceae family [1]. Okra is native to Ethiopia and Sudan in Northeastern Africa [2]. It is a self-pollinated, seed-propagated annual herbaceous plant [3, 4]. Okra is grown in tropical, subtropical, and warm temperate regions of the world [5, 6]. It is highly nutritious [7] and has economic and industrial value [8]. The nutritional values of okra include carbohydrates, protein, fiber, thiamine, riboflavin, and ascorbic acid [9]. Immature green fruits and fresh leaves of okra are used in salads, soups, and stews [10], and dried seeds are used to make vegetable curd or roasted and ground and used as an additive or substitute for coffee [11]. Okra is mainly grown in the western part of Ethiopia, but there is no complete data on okra production and productivity within the country [12].

The hard seed coat of okra inhibits water uptake and is an important physiological constraint for uniform stand establishment and performance [13, 14]. Genotypes, pod harvest time, and seed priming have been reported to influence on okra seed germination and vigor [15, 16]. Although there is no information on genetic variation in Ethiopia okra germplasm for seed hardness, the presence of genetic diversity in other traits of the crop has been reported [12, 17]. Hence, it is possible to predict the presence of variations in okra germplasm in the Ethiopian okra germplasm for many agromorphological traits, including seed hardness. However, there is no information on the seed quality of okra germplasm in Ethiopia.

Seed priming is a simple, inexpensive, and effective method to synchronized germination and early seedling growth by increasing the speed of germination, seed vigor and overcoming dormancy, and allowing better establishment and high-quality yields of plants in stressful and stress-free environmental conditions [18–20]. However, there is no recommended seed priming method to overcome the seed hardness of the okra genotypes and no information on seed quality differences between okra germplasm from Ethiopia and commercial varieties from other countries. Therefore, this study was initiated to assess the impact of seed priming on seed physiological quality of okra genotypes.

2. Materials and Methods

2.1. Experimental Materials. A total of five okra genotypes; two genotypes were collected from Ethiopia (240586 and 240207), one variety was from the USA (Clemson), and the other two varieties were introduced from India (SOH701 and Arka Anamika) were used for this experiment. Seeds of these five genotypes were harvested in November 2019 at Tony Farm, a research site of Haramaya University in Dire Dawa, Ethiopia (9°36′N, 41°52′E and longitude 60°N, 41.867°E) [21]. The harvested seeds from each genotype were kept in canvas bags and kept at room temperature at the horticultural laboratory at Haramaya University, and various seed primings, including tap water, 50% cow urine, 0.5% KH_2PO_4, and 200 ppm GA_3, were used for this experiment.

2.2. Treatments and Experimental Design. The experiment consisted of five seed priming methods (untreated seeds, tape water, 200 ppm GA_3, 0.5% KH_2PO_4, and 50% cow urine) and five okra genotypes, two of which were collected from Ethiopia (240586 and 240207), one from the United States (Clemson), and the other two (SOH701 and Arka Anamika) were brought over from India. Therefore, there were 25 treatments in the factorial arrangement. Except for the control treatment, all five okra genotypes were treated with each seed priming method for 24 hours and shade dried for 6 hours before sowing. The experiment was conducted in January 2020 in a laboratory at Haramaya University, Ethiopia, in a completely randomized design (CRD) with 4 replicates. For each replicate, hundred seeds were used per treatment.

2.3. Data Collection

2.3.1. Seed Quality Parameters

(1) Hundred Seed Weight (g). A hundred seeds of each genotype were randomly selected from four replications, weighed, adjusted to have 12% moisture content, and recorded as the hundred seed weight.

(2) Seed Moisture Content (%). Five grams of seeds from each genotype with four replications were taken from the sample seeds, and the seeds were ground, weighed, poured into small covered containers, and kept in an oven maintained at a temperature of 103°C for 17 hours. The moisture content of the seeds was then determined by the following formula (1):

$$\textbf{Moisture content}\,(\%) = \frac{(M_2 - M_3)}{(M_2 - M_1)}\text{x}100\%. \quad (1)$$

Note: M_1, weight in grams of the container and its cover, M_2, weight in grams of the container, its cover + ground material before drying, and M_3, weight in grams of the container, its cover + ground material after drying.

(3) Normal Seeds (%). Hundred randomly taken seeds of each genotype with four replications were classified as normal and abnormal seeds. Seeds were considered normal if they were well filled (not wrinkled), were of average seed size in the sample, and had not developed any symptoms of rot. Seeds wrinkled, cracked, broken, partially or completely missing seed coat, very small or large seeds, extensive rot, and symptoms of other diseases were considered as abnormal seeds. The normal seeds were counted and calculated the seed percentage as follows:

$$\textbf{Normal seeds}\,(\%) = \frac{\text{number of normal seeds}}{\text{total number of seeds}}\text{x}100\%. \quad (2)$$

(4) Seed Germination (%). A total of four hundred seeds (four replications of 100 seeds) were used in the germination test for each treatment. In sterile petri dishes, hundred seeds from each treatment were placed on filter paper that had been moistened with distilled water. Finally, the petri dishes were placed in a growth chamber at 25°C for 21 days, and the seeds were then kept moist with distilled water for 21 days in the laboratory. Germinated seedlings were counted starting with the first seedling that germinated and ending 21 days after placing the seeds in the petri dish. At the end of this test, the seeds were classified as germinated, fresh ungerminated, hard, or dead seeds. Germinated seeds were used to calculate the seed germination percentage [22].

$$\textbf{Germination}\,(\%) = \frac{\text{Number of germinated seeds}}{\text{Total number of seeds sown}}\text{x}100. \quad (3)$$

(5) Hard Seeds (%). Hard seeds do not absorb water and remain rigid at the end of the germination test. So, at the end of the germination test, count the hard seeds, and calculate the percentage of these seeds as follows [23]:

$$\textbf{Hard seeds}\,(\%) = \frac{\text{Number of hard seeds}}{\text{Total number of seeds sown}}\text{x}100. \quad (4)$$

(6) Viability (%). Viability was determined from germinated and fresh ungerminated seed (seeds that have absorbed water and imbibition but have not germinated) using the formula shown in the following [24]:

$$\textbf{Viability}\,(\%) = \frac{\text{Number germinated + fresh seeds}}{\text{Total number of seeds sown}} \text{x100}. \quad (5)$$

(7) Speed of Germination. The number of germinated seeds was counted every two days until the end of the germination test. An index was calculated by dividing the number of seeds that germinated each day by the number of days that were in the petri dish [25].

$$\textbf{Speed of Germination} = \frac{N1}{C1} + \frac{N2}{C2} + \ldots + \frac{NF}{CF}. \quad (6)$$

Note: N1 (number of germinated seeds at first count), N2 (Number of germinated seeds at the second count), Nf (number of germinated seeds at the final count), C1 (days to first count), C2 (days to the second count), and Cf (days to the final count)

Table 1: The mean squares from the analysis of variance for the physical seed quality test of prepriming seed of five okra genotypes.

Sources	DF	Seed moisture content (%)	Number of normal seeds	Hundred seeds weight (g)
Genotype	4	10.5843**	139.7**	4.7520**
Error	15	0.2328	31.5	0.4007

*Note.***, 1% level significance; DF, degree of freedom.

(8) Seedling Length (cm). Normal seedling length was measured (roots and shoots separately) according to International Seed Testing Association (ISTA) [22] at the end of the germination experiment.

Seed vigor index I is calculated as follows:

$$\textbf{Seed vigor index I} = \text{Germination percentage}\,(\%)\text{x seedl ing length}\,(\text{cm}). \quad (7)$$

(9) Seedling Dry Weight (mg). At the end of the germination experiment, the normal seedlings without cotyledons were dried in an oven maintained at a temperature of 103°C for 48 hours, after which the seedlings were transferred from the oven to an activated silica gel desiccator and left for 30 minutes. Seedling dry weight was measured in grams using a sensitive balance, according to ISTA [22].

Seed Vigor Index II is calculated as

$$\textbf{Seed vigor index II} = \text{Germination percentage x seedl ing dr y weight}\,(\text{mg}). \quad (8)$$

2.4. Data Analysis. Data were subjected to analysis of variance (ANOVA) using GenStat software (16^{th} edition), following the statistical procedures outlined in Gomez and Gomez [26]. Prior to analysis, the percentage data was transformed using the arcsine transformation technique. The mean separation was performed at the 1% or 5% level of the least significant difference (LSD). The correlations between seed quality attributes were estimated using STATISTICA 7 (U.S.A., 2002) statistical software.

3. Results and Discussion

3.1. Effect of Genotype on Seed Moisture, Normal Seed Number, and Seed Weight. The physical seed quality of the five okra genotypes was tested before the application of the priming treatments. Analysis of variance revealed significant differences in seed moisture content, number of normal seeds, and hundred seed weight among the five okra genotypes ($p < 0.01$) (Table 1). The highest seed moisture content (11.97%) was measured with the genotype Clemson, with no significant difference from the moisture content of genotype Arka Anamika seeds. Genotype Clemson also had the lowest number of normal seeds (85.75%) and 100 seed weights (3.05 g). In contrast, genotype 240586 had significantly lower seed moisture content (8.18%) and a significantly higher weight of 100 seeds (5.55 g), statically equal to genotype 240207. Genotype Arka Anamika had a significantly higher number of normal seeds (93.25%) with no significant difference from the number of normal seeds of genotype 240586 (Table 2). The results showed that the genotypes had inherent differences with respect to seed physical quality parameters. Similar results were reported by Balla [27].

3.2. Effect of Seed Priming on Seed Physiological Quality of Okra Genotypes. All physiological seed quality parameters of okra genotypes, including germination percentage, speed of germination, seed viability, seedling length, seedling dry weight, seed vigor index I and II, and number of hard seeds were significantly influenced by genotype differences and seed priming. Except for seed viability, the interaction of genotype and seed priming also affected all of the above-mentioned physiological seed quality parameters and the number of hard seeds (Table 3).

3.2.1. Effects of Genotype and Seed Priming on Seed Viability. The main effects of genotype and different seed priming treatments significantly ($p < 0.01$) affected the seed viability (Table 3). In contrast, the interaction effects of genotype and different seed priming treatments were not significantly ($p < 0.05$) affected the seed viability (Table 3). Genotype Arka Anamika showed significantly higher (72.12%) seed viability with no significant difference from genotypes Clemson and SOH701. In contrast, genotype 240586 had significantly lower (67.48%) seed viability without significant

Table 2: Effect of okra genotypes on seed moisture content, number of normal seed, and seed weight.

Genotypes	Seed moisture content (%)	Number of normal seeds (%)	Hundred seeds weight (g)
Clemson	11.97[a]	85.75[d]	3.05[c]
Arka Anamika	11.55[a]	93.25[a]	4.65[b]
SOH701	10.30[b]	88.00c	4.85[b]
240586	8.18[d]	91.50[ab]	5.85[a]
240207	8.97[c]	90.50[b]	5.55[ab]
LSD (5%)	0.73	2.18	0.95
CV (%)	4.7	1.6	13.2

Note. Mean values within a column followed by the same letter (s) of each trait (s) are not significantly different at 5% probability level; LSD, least significant difference; CV (%), coefficient of variation in percent.

Table 3: Analysis of variance mean squares for the physiological seed quality test and number of hard seed for five okra genotypes as influenced by priming.

Sources	DF	Germination (%)	Germination speed (per day)	Hard seed (%)	Seedling length (cm)	Seed vigor index I	Seedling dry weight (mg)	Seed vigor index II	Viability (%)
Genotype	4	92.84**	108.738**	361.82**	2.3742**	4.5763**	1060.486**	723.787**	64.7**
Priming	4	212.43**	383.154**	726.869**	44.5434**	57.8906**	1942.866**	1617.599**	162.59**
Genotype* priming	16	32.29*	16.611**	32.965**	2.0154**	2.0871**	345.660**	277.293**	32.25[ns]
Error	75	17.43	4.03	4.053	0.318	0.5582	2.216	2.390	22.68

Note. ns, nonsignificant difference; * and **, significant at 5% and 1% level of significance, respectively; DF, degree of freedom.

Table 4: Main effects of genotype and seed priming on okra seed viability.

Treatments	Seed viability (%)
Genotype	
Clemson	71.16[ab] (88.9)
Arka Anamika	72.12[a] (90)
SOH701	70.53[ab] (88.3)
240586	67.48[b] (84.8)
240207	69.28[ab] (86.4)
LSD (5%)	3
CV (%)	6.8
Seed priming	
Control	66.87[b] (84.3)
Tap water	70.65[ab] (88.0)
GA_3	74.59[a] (92.1)
KH_2PO_4	69.08[b] (86.8)
Cow urine	69.37[b] (87.2)
LSD (5%)	3
CV (%)	6.8

Note. Mean values within a column followed by the same letter (s) trait are not significantly different at 0.05 probability level; LSD, least significant difference; CV (%), coefficient of variation in percent, and the value in the bracket is the original (nontransformed) data.

difference to genotype 240207 (Table 4). The observed variability in results may be due to the genetic factors of the okra genotypes. In general, the results showed that the seed viability of the Ethiopian genotypes were lower than that of the introduced genotypes. This result is in agreement with other researchers, marking notable significantly varied in seed viability percentage across ten okra genotypes [28].

Okra seeds primed with GA_3 resulted in significantly higher seed viability (74.59%) than other treatments. In contrast, the seed viability of untreated seeds was significantly lower (66.87%) and not significantly different from KH_2PO_4 and cow urine-treated seeds (Table 4). The results showed that different seed priming treatments affected the viability of okra seeds in different ranges. The highest seed viability with GA_3 treatment was due to the fact that GA_3 promotes early DNA replication, recovered seed damage and deterioration, increases RNA and protein synthesis, and increases ATP availability in seeds [29]. The present result is consistent with the studied by [20, 30].

3.2.2. Effects of Genotype and Seed Priming on Germination Percentage. The main effects of genotype and different seed priming treatments significantly ($p < 0.01$) affected the germination percentage (Table 3). Similarly, the two factors interact significantly to influence germination percentage ($p < 0.05$) (Table 3). Genotype Clemson seeds treated with GA_3 showed a significant increase in the germination percentage (78.28%) with no significant difference from the germination percentage of genotypes SOH701 and Arka Anamika seeds treated with GA_3, and genotypes Arka Anamika and Clemson treated with tap water. In contrast, the germination percentage of untreated seeds of genotype 240586 was significantly lower (59.16%) and not significantly different from that of untreated seeds of genotype 240207 (Table 5).

In general, primed seeds of okra genotypes in GA_3 increased the germination percentage, ranging from 7.5% (240207) to 14.5% (Clemson) compared to untreated seeds of the respective genotypes. Seeds treated with tap

Table 5: Interaction effects of genotype and different priming on germination percentage, germination speed, and number of hard seeds.

Treatments		Parameters		
Genotype	Seed priming	Germination (%)	Germination speed (per day)	Hard seed (%)
Clemson	Control	64.32^{cde} (81.0)	$10.91^{j–m}$	14.18^{cde} (6.00)
	Tap water	$71.12^{a–d}$ (89.0)	17.53^{cd}	2.88^{hij} (1.00)
	GA_3	78.28^{a} (95.5)	25.29^{a}	0.00^{j} (0.00)
	KH_2PO_4	$69.97^{a–e}$ (87.5)	17.63^{c}	2.03^{ij} (0.50)
	Cow urine	$66.01^{b–e}$ (83.0)	17.38^{cde}	0.00^{j} (0.00)
Arka Anamika	Control	$66.5^{b–e}$ (84.0)	9.13^{im}	16.94^{bc} (8.50)
	Tap water	$71.04^{a–d}$ (89.0)	$16.97^{c–f}$	2.87^{hij} (0.50)
	GA_3	74.79^{abc} (93.0)	21.19^{b}	2.87^{hij} (0.50)
	KH_2PO_4	$66.5^{b–e}$ (84.0)	$14.72^{d–g}$	$9.51^{d–g}$ (2.75)
	Cow urine	$68.75^{a–e}$ (86.5)	$13.09^{g–j}$	11.54^{def} (4.00)
SOH701	Control	$68.48^{a–e}$ (86.5)	10.05^{klm}	17.46^{bc} (9.00)
	Tap water	$69.83^{a–e}$ (87.5)	13.96^{ghi}	2.87^{hji} (0.50)
	GA_3	76.47^{ab} (94.0)	24.49^{a}	0.00^{j} (0.00)
	KH_2PO_4	$68.43^{a–e}$ (86.0)	$14.29^{f–i}$	8.13^{fgh} (2.00)
	Cow urine	$65.83^{b–e}$ (83.0)	$11.84^{h–l}$	9.05^{efg} (2.50)
240586	Control	59.16^{e} (73.5)	8.24^{m}	24.34^{a} (17.00)
	Tap water	63.89^{cde} (80.5)	$12.31^{g–k}$	14.76^{bcd} (6.50)
	GA_3	$68.43^{a–e}$ (86.0)	$12.8^{g–k}$	$12.23^{c–f}$ (4.50)
	KH_2PO_4	$66.48^{b–e}$ (84.0)	$10.96^{j–m}$	$12.20^{c–f}$ (4.50)
	Cow urine	$67.33^{a–e}$ (85.0)	$11.67^{i–l}$	11.49^{def} (4.00)
240207	Control	62.14^{de} (78.0)	8.38^{m}	20.04^{ab} (11.75)
	Tap water	$66.26^{b–e}$ (83.5)	$13.02^{g–j}$	0.00^{j} (0.00)
	GA_3	$68.13^{a–e}$ (86.0)	23.64^{ab}	2.87^{hij} (0.50)
	KH_2PO_4	$66.01^{b–e}$ (83.0)	$14.61^{e–h}$	0.00^{j} (0.00)
	Cow urine	$72.25^{a–d}$ (90.5)	$12.69^{g–k}$	5.74^{ghi} (1.00)
LSD (5%)		5.88	2.83	2.84
CV (%)		6.1	13.7	24.7

Note. Mean value within columns followed by the same letter (s) of trait (s) were not significantly different at 5% probability level; LSD, least significant difference; CV (%), is coefficient of variation in percent; GA_3, gibberellic acid; KH_2PO_4, potassium dihydrogen phosphate; and the value in the bracket is the original (nontransformed) data.

water and KH_2PO_4 increased the germination percentages of all five okra genotype seeds by 2.5 to 9%. Seeds treated with cow urine for genotype 240207 had a 4.5% reduction in germination percentage, while seeds of other genotypes treated with cow urine had increase a germination percentage from 1 (240586) to 12.5% (Clemson). The results showed that the germination of seeds of all genotypes increased better when treated with GA_3, but the magnitude of the increase differed by genotype. Seeds treated with other priming treatments also showed a different amount of increase in germination percentages across genotypes compared to untreated seeds.

The enhanced germination observed in seed priming treatments might be due to the fact that the seeds were completing the pregermination process during seed priming, and GA_3 might affect the synthesis of hydrolyzing enzymes, particularly amylase and protease and the hydrolyzed food was utilized by the growing embryo and thereby enhancing the germination of seeds [31, 32]. Consistent with others, the present results also showed a significant increase in germination percentage with different priming treatments [33]. Seeds primed with cow urine had a 15.6% higher germination percentage than untreated seeds of cotton [34].

3.2.3. Effects of Genotype and Seed Priming on Speed of Germination. Analysis of variance results showed that both the main and interaction effects of genotype and different seed priming treatments significantly ($p < 0.01$) affected the speed of germination (Table 3). Genotype Clemson, followed by SOH701 and 240207, treated with GA_3, showed significantly higher speed of germination than other treatment combinations, with no statically significant difference among themselves. Untreated seeds of genotypes 240586 and 240207 showed a lower speed of germination, but there was no statistically significant difference in the speed of germination in untreated seeds of all other genotypes (Table 5). Increased speed of germination by seed priming treatment might be due to the completion of pregermination metabolic activity of seeds and the seed ready for radical protrusion [31]. The result is in agreement with the findings of other researchers [35].

3.2.4. Effects of Genotype and Seed Priming on Number of Hard Seed. Analysis of variance results showed that both the main and interaction effects of genotype and different seed priming treatments significantly affected the number of hard seeds ($p < 0.01$) (Table 3). There were no hard seeds in genotype Clemson treated in GA_3 and cow urine, genotype

SOH701 treated in GA_3, and genotype 240207 treated in tap water and KH_2PO_4. In contrast, untreated seeds of genotype 240586 had a significantly higher number (24.34%) of hard seeds than all other treatment combinations. Moreover, this genotype showed a persistently high percentage of hard seeds across different seed priming treatments (Table 5). In general, genotypes showed different responses to different seed priming treatments in terms of seed hardiness percentage. The results showed that the seed priming treatment significantly reduced the percentage of hard seeds in all tested okra genotype seeds. This may be due to the softening effect of the hard seed coat, the leaching of inhibitors, and the stimulation of hydrolytic enzymes required for the degradation of the cells surrounding the radicle, thereby suppressing the radicle [31]. Similar observations have been reported by other researchers [16, 23].

3.2.5. Effects of Genotype and Seed Priming on Seedling Length. Analysis of variance results showed that both the main and interaction effect of genotype and different seed priming treatments significantly ($p < 0.01$) affected seedling growth (Table 3). The seeds of genotype 240207, followed by genotypes 240586 and SOH701 treated with GA_3 had significantly longer seedlings without significance difference among their mean values. In contrast, the untreated seeds of genotype 240207 had significantly shortest seedling length without significant difference with the untreated seeds of genotype Arka Anamika and Clemson (Table 6). In general, primed seeds of okra genotypes by GA_3 increased the seedling length in the range between 36.5% (Clemson) and 61.6% (240207) compared to untreated seeds of the respective genotypes. Seeds of genotypes SOH701 and 240586 treated in tap water showed a slight reduction in seedling length, while in the other genotypes 3.8–27.8% increments was observed. Similarly, KH_2PO_4 and cow urine also increased the seedling length, except in genotype SOH701 in the range from 7.7%, genotype 240586 treated with KH_2PO_4 to 20.6% of genotype Arka Anamika treated with cow urine.

Results showed an increase in seedling growth, but the extent of the increase varied by genotype. This pointed to different genotypes responding differently to different seed priming treatments for seedling growth. A possible reason for the longer seedling length of genotypic seeds from seed priming was earlier germination. This could be because seedling growth was improved and GA_3 increased cell division, causing elongation and an increase of seedling roots and shoots within the apical meristem of seedlings [36]. Therefore, seed priming using GA_3 can be successfully used to promote okra seed germination and seedling growth. Cow urine and KH_2PO_4 may also affect longer seedlings by providing nutrients and growth-promoting bioactives [37]. The present results correspond to those of Sanodiya et al. [35].

3.2.6. Effects of Genotype and Seed Priming on Seedling Dry Weight. Analysis of variance results showed that both the main and interaction effects of genotype and different seed priming treatments significantly ($p < 0.01$) affected seedling dry weight (Table 3). Genotype 24027 followed by genotype 240586 seeds treated with GA_3 showed significantly higher seedling dry weight, but there was no significant difference between the two. In contrast, untreated seeds of genotype SOH701 had significantly lower seedling dry weight, followed by the seedling dry weights of other untreated and tap water-treated genotypes, except for genotype 240586 (Table 6). Increased seedling dry weight in seed priming may be due to increased seedling fresh weight, seedling length, and increased dry matter accumulation due to earlier germination and growth [20]. This result is consistent with that of other researchers [30].

3.2.7. Effects of Genotype and Seed Priming on Seedling Vigor Index I. Both the main and interaction effect of genotype and different seed priming treatments ($p < 0.01$) significantly affected seedling vigor index I (Table 3). Seeds of all genotypes treated with GA_3 had significantly higher seedling vigor index I than other treatment combinations. In contrast, untreated seeds of all genotypes, except SOH701 had the lowest seedling vigor index I without significant differences among them (Table 6). In general, treated seeds of okra genotypes in GA_3 increased seedling vigor index I, ranging from 23.5% (SOH701) to 78.6% (240207) compared to untreated seeds of the respective genotypes. Seeds treated in tap water improved the seedling vigor index I by about 13.7% to 24.2%, except for SOH701. Similarly, KH_2PO_4 and cow urine also increased the seedling vigor index I of genotypes other than SOH701 by approximately 18.3% to 28.2% and approximately 17.2% to 34.4%, respectively. The results showed that priming of seeds with GA_3 increased the vigor index I of seeds of all genotypes, seeds treated with other seed priming treatments also showed different seed vigor index I, along with increases in most genotypes. In general, the results showed that seeds of different okra genotypes showed different responses to different seed priming treatments for seed vigor index I. The increase in seed vigor index by seed priming may be due to the fact that the seed priming treatment is appropriate for the metabolic response, improving seed germination performance and seedling growth [36]. The current result is consistent with the results of Kaura et al. [38].

3.2.8. Effects of Genotype and Seed Priming on Seedling Vigor Index II. Both the main and interaction effect of genotype and different seed priming treatments ($p < 0.01$) significantly affected seedling vigor index II (Table 3). Genotype 240586 seeds treated with GA_3 had a significantly higher seed vigor index II, with no significant difference from the genotype 240207 seeds treated with GA_3. Whereas untreated and tap water-treated seeds of all genotypes, GA_3-treated seeds of genotype SOH701, KH_2PO_4-treated seeds of genotypes Clemson and 240207 and cow urine-treated seeds of genotype Clemson and Arka Anamika showed low seed vigor index II, which were statistically at par with each other (Table 6). The results showed that priming of seeds with GA_3 increased the vigor index II of seeds of most genotypes, but the magnitude of the increase differed by genotype. The

Table 6: Interaction effects of genotype and different priming on seedling length, dry weight, and seed vigor index I and II.

Treatments		Parameters			
Genotype	Seed priming	Seedling length (cm)	Seedling dry weight (mg)	Seed vigor index I	Seed vigor index II
Clemson	Control	9.68^{jk}	4.36^{i}	7.852^{ghi}	3.53^{fg}
	Tap water	10.65^{hi}	$5.64^{e–i}$	9.477^{de}	5.03^{efg}
	GA_3	13.21^{c}	28.49^{d}	12.611^{a}	27.20^{d}
	KH_2PO_4	11.46^{efg}	$5.43^{f–i}$	10.039^{bcd}	4.77^{efg}
	Cow urine	$11.09^{e–h}$	$5.57^{e–i}$	9.204^{def}	4.62^{efg}
Arka Anamika	Control	9.21^{k}	4.85^{ghi}	7.719^{hi}	4.07^{fg}
	Tap water	11.77^{de}	3.94^{i}	10.537^{bc}	3.50^{fg}
	GA_3	13.86^{bc}	33.00^{c}	12.893^{a}	30.71^{c}
	KH_2PO_4	10.88^{gh}	7.52^{ef}	9.135^{def}	6.34^{e}
	Cow urine	$11.11^{e–h}$	4.78^{ghi}	9.594^{cde}	$4.13f^{g}$
SOH701	Control	12.32^{d}	3.87^{i}	10.659^{b}	3.35^{g}
	Tap water	10.94^{fgh}	$5.50^{f–i}$	9.573^{cde}	4.80^{efg}
	GA_3	14.00^{abc}	$4.53^{h–i}$	13.161^{a}	4.26^{efg}
	KH_2PO_4	11.71^{def}	$6.47^{e–h}$	$10.067^{b–d}$	5.58^{ef}
	Cow urine	$11.17^{e–h}$	7.65^{e}	9.273^{def}	6.33^{e}
240586	Control	10.03^{ij}	6.85^{efg}	7.362^{hi}	5.05^{efg}
	Tap water	10.40^{hij}	$6.58^{e–h}$	8.369^{fgh}	5.29^{efg}
	GA_3	14.16^{ab}	39.67^{a}	12.171^{a}	34.14^{a}
	KH_2PO_4	10.8^{ghi}	36.39^{b}	9.061^{def}	30.59^{c}
	Cow urine	$11.54^{d–g}$	30.03^{d}	$9.81^{b–e}$	25.51^{d}
240207	Control	9.11^{k}	5.30^{ghi}	7.091^{i}	4.14^{fg}
	Tap water	10.56^{hi}	$5.46^{f–i}$	8.809^{efg}	4.55^{efg}
	GA_3	14.72^{a}	39.36^{a}	12.665^{a}	33.86^{ab}
	KH_2PO_4	10.94^{fgh}	5.41^{ghi}	9.089^{def}	4.50^{efg}
	Cow urine	10.54^{hi}	35.16^{b}	9.529^{cde}	31.76^{bc}
LSD (5%)		0.79	2.10	1.05	2.18
CV (%)		4.9	10.9	7.6	13

Note. Mean value within columns followed by the same letter (s) of trait (s) were not significantly different at 5% probability level; LSD, least significant difference; CV (%), is coefficient of variation in percent; GA_3, gibberellic acid; KH_2PO_4, potassium dihydrogen phosphate.

Table 7: Correlation coefficients for seed quality parameters as affected by genotype and seed priming treatments.

Parameters	GS	HS (%)	SV (%)	SL (cm)	SVI	SDW (mg)	SVII
Seed germination (%)	0.95^{**}	-0.68^{**}	0.99^{**}	0.88^{**}	0.80^{**}	0.78^{**}	0.81^{**}
Germination speed (per day)		-0.69^{**}	0.68^{**}	0.74^{**}	0.81^{**}	0.49^{**}	0.53^{**}
Hard seed (%)			-0.70^{**}	-0.49^{**}	-0.53^{**}	-0.54^{**}	-0.54^{**}
Seed viability (%)				0.87^{**}	0.91^{**}	0.78^{**}	0.80^{**}
Seedling length (cm)					0.99^{**}	0.90^{**}	0.92^{**}
Seed vigor index I						0.89^{**}	0.91^{**}
Seedling dry weight (mg)							0.99^{**}
Seed vigor index II							

Note.**, highly significant at 0.01 levels; GS, germination speed; HS, hard seed; SV, seed viability; SL, seedling length; SVI, seed vigor index I; SDW, seedling dry weight; SVII, seed vigor index II.

increase in seed vigor index by seed priming may be due to the fact that the priming treatment is appropriate for metabolic response, improving seed germination performance and seedling growth [36]. In general, the results showed that seeds of different okra genotypes showed different responses to different seed priming treatments for seed vigor index II. The current result is consistent with the results of Kaura et al. [38].

3.3. Correlation of Seed Quality Parameters. The correlation analysis showed that seed germination percentage, speed of germination, seed viability, seedling length, seedling dry weight, and seed vigor indices I and II had highly significant with positive correlations with each other. In contrast, hard seeds had highly significant with negative correlations with germination percentage, speed of germination, seed viability, seedling length, seedling dry weight, and seed vigor indices I and II (Table 7). High germination percentages, viability, and rapid seedling growth are characteristics of vigorous seeds. The ability of a seed to germinate, together with its germination percentage, germination speed, and seedling growth, are all combined to form seed vigor. Therefore, the potential performance of viable seeds is

described by seed germination and vigor. Germination uniformity, germination speed, and seedling growth are the three basic aspects of seed vigor [39, 40]. Seed vigor index is directly reflected in seed germination percentage and seedling growth. The other most important factor affecting the seed vigor index is speed of germination, which is also the seed germination parameter and most strongly linked to seed germination and vigor [41, 42]. Hard seed, on the other hand, hinders uniform germination, slows germination speed, and reduces the germination of the seed because it restricts water absorption in the seeds, which has an impact on the seed germination and establishment of seedlings. As a result, there is a negative correlation between hard seed and the abovementioned seed quality parameters.

4. Conclusion

In general, the study results showed that seeds of different okra genotypes showed different responses to different seed priming treatments for seed quality. The seeds of okra genotypes treated by different seed priming treatments on seed germination, seed vigor, and reduction of seed hardiness revealed that the GA_3 seed priming treatment was better than any other seed priming treatment. Tap water, cow urine, and KH_2PO_4 seed priming treatments can be used as an alternative to GA_3 seed priming treatment. Seed priming treatment is therefore a useful technique for improving the germination percentage, speed of germination, seedling growth, seed vigor, and reducing seed hardiness of okra seeds. Yet, more research is needed to know the effects of different seed priming treatments on the morphological traits and yield of okra genotypes.

Data Availability

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Conflicts of Interest

The author declares that there are no conflicts of interest.

Acknowledgments

The author would like to express special thanks to the Department of Horticulture, Haramaya University, for providing resources, support, and guidance during the study.

References

[1] A. Naveed, A. A. Khan, and I. A. Khan, "Generation means analysis of water stress tolerance in okra [*Abelmoschus esculentus* (L.) Moench]," *Pakistan Journal of Botany*, vol. 41, no. 1, pp. 195–205, 2009.

[2] B. M. Santos, P. J. Dittmar, S. M. Olson, S. E. Webb, and S. Zhang, *Okra Production in Florida*, pp. 163–171, University of Florida IFAS extension, Gainesville, FL, USA, 2012.

[3] F. W. Martin and A. M. Rhodes, "Seed characteristics of okra and related *Abelmoschus* species," *Qualitas Plantarum Plant Foods for Human Nutrition*, vol. 33, no. 1, pp. 41–49, 1983.

[4] M. E. Osawaru, M. C. Ogwu, and J. Omologbe, "Characterization of three Okra [Ablemoschus esculentus (L.)] accessions using morphology and SDS-PAGE for the basis of conservation," *Egyptian Academic Journal of Biological Sciences H. Botany*, vol. 5, no. 1, pp. 55–65, 2014.

[5] K. Kamalpreet, P. Mamta, K. Satinder, P. Dharminder, and C. Neena, "Assessment of morphological and molecular diversity among okra [*Abelmoschus esculentus* (L.) Moench.] germplasm," *Acad´emica*, vol. 12, no. 21, pp. 3160–3170, 2013.

[6] C. Y. Yuan, C. Zhang, P. Wang et al., "Genetic diversity analysis of okra (*Abelmoschus esculentus* L.) by inter-simple sequence repeats (ISSR) markers," *Genetics and Molecular Research*, vol. 13, no. 2, pp. 3165–3175, 2014.

[7] H. D. Tindall, *Vegetables in the Tropics*, Macmillan Education Limited, London, UK, 1983.

[8] W. J. Lamont, "Okra A versatile vegetable crop," *HortTechnology*, vol. 9, no. 2, pp. 179–184, 1999.

[9] A. A. Fajinmi and O. B. Fajinmi, "Incidence of okra mosaic virus at different growth stages of okra plants [*Abelmoschus esculentus* (L.) Moench] under tropical condition," *Journal of General and Molecular Virology*, vol. 2, no. 1, pp. 028–031, 2010.

[10] N. M. Salameh, "Genetic diversity of okra (*Abelmoschus esculentus* L.) landraces from different agro-ecological regions revealed by AFLP analysis," *American-Eurasian Journal of Agricultural & Environmental Sciences*, vol. 14, pp. 155–160, 2014.

[11] T. Moekchantuk and P. Kumar, "Export okra production in ailand," *Intercountry Programme for Vegetable IPM in South & SE Asia Phase II Food and Agriculture Organization of the United Nations Bangkok'ailand*, vol. 56, 2004.

[12] M. Yonas, W. Garedew, and A. Debela, "Variability and association of quantitative characters among okra [*Abelmoschus esculentus* (L.) Moench] collection in South Western," *Journal of Biological Sciences*, vol. 14, no. 5, pp. 336–342, 2014.

[13] L. C. Standifer, P. W. Wilson, and A. Drummond, "The effect of seed moisture content on hardseededness and germination in four cultivars of okra (*Abelmoschus esculentus* (L.) Moench)," *Plant Varieties and Seeds*, vol. 2, pp. 149–154, 1989.

[14] G. Mohammadi, E. M. Khah, and M. Bannayan Aval, "Differential responses for harvesting times and storage on hardness of different varieties of okra," *Notulae Scientia Biologicae*, vol. 3, no. 4, pp. 117–122, 2011.

[15] L. F. V. Purquerio, A. A. d. Lago, and F. A. Passos, "Germination and hardseedness of seeds in okra elite lines," *Horticultura Brasileira*, vol. 28, no. 2, pp. 232–235, 2010.

[16] G. Mohammadi, M. E. Khah, J. S. Honarmand, A. Shirkhani, and G. Shabani, "Effect of seed hardness breaking techniques on okra (*Abelmoschus esculentus* L.) germination," *The International Journal of Agriculture and Crop Sciences*, vol. 4, no. 6, pp. 264–273, 2012.

[17] B. Tesfa and A. Yosef, "Characterization of okra [*Abelmoschus esculentus* (L.) Moench] germplasms collected from Western Ethiopia," *International Journal of Research in Agriculture and Forestry*, vol. 3, no. 2, pp. 11–17, 2016.

[18] L. Ventura, M. Donà, A. Macovei et al., "Understanding the molecular pathways associated with seed vigor," *Plant Physiology and Biochemistry*, vol. 60, pp. 196–206, 2012.

[19] S. Paparella, S. S. Araujo, G. Rossi, M. Wijayasinghe, D. Carbonera, and A. Balestrazzi, "Seed priming: state of the

art and new perspectives," *Plant Cell Reports*, vol. 34, no. 8, pp. 1281–1293, 2015.

[20] J. H. Hussein, "Effect of seed priming treatment with salicylic acid on viability of okra (*Abelmoschus esculentus* L.) seeds," *Euphrates Journal of Agriculture Science*, vol. 7, no. 2, pp. 1–9, 2015.

[21] D. T. Hailay, M. Lipsitch, T. Awash, P. Dharminder, and J. Schwartz, "Weather-based prediction of Plasmodium falciparum malaria in epidemic-prone regions of Ethiopia I," *Patterns of lagged weather effects reflect biological mechanisms, Malaria Journal*, vol. 3, no. 41, pp. 1–11, 2004.

[22] Ista, *International Seed Testing Association. International Rules for Seed Testing*, International Seed Testing Association, Switzerland, 2014.

[23] C. Musara, J. Chitamba, and C. Nhuvira, "Evaluation of different seed dormancy breaking techniques on okra (*Abelmoschus esculentus* L.) seed germination," *African Journal of Agricultural Research*, vol. 10, no. 17, pp. 1925–1956, 2015.

[24] R. Davies, A. Sacco, and R. Newton, "Germination testing: procedures and evaluation," *Royal Botanic Gardens, Kew. Technical Information Sheet*, vol. 13, 2015.

[25] M. M. Sahib, A. N. Hamzah, and J. H. Husseine, "Effect of seed priming by KH_2PO_4 and different temperature on seeds germination behavior of okra (Abelmoschus *esculentus* L.)," MSc Thesis, University of Qadesyia Babylon, Al Diwaniyah, Iraq, 2014.

[26] K. A. Gomez and A. A. Gomez, *Statistical Procedure for Agricultural Research*, John Wiley & Sons, New York, USA, 1987.

[27] M. M. A. El Balla, A. I. Saidahmed, and M. Makkawi, "Effect of moisture content and maturity on hardseededness and germination in okra (*Abelmoschus esculentus* (L.) Moench)," *International Journal of Plant Physiology and Biochemistry*, vol. 3, no. 6, pp. 102–107, 2011.

[28] Y. S. Sankar and M. Arghya, "Studies on seed quality parameter of okra (*Abelmoschus esculentus* L.)," *Journal of Agriculture and Technology*, vol. 2, no. 2, pp. 79–83, 2015.

[29] P. Junhaeng, P. Thobunluepop, W. Chanprasert, and S. Nakasthien, "The use of seed priming treatments to improve the quality of barley (*Hordeum vulgare* **L.**) for mating," *Journal of Developments in Sustainable Agriculture*, vol. 10, pp. 115–120, 2015.

[30] J. H. Hussein, "Effect of seed priming with salicylic acid and ascorbic acid on viability of local okra (*Abelmoschus esculentus* L.) seeds stored for three years," *Journal of Global Pharmacy Technology*, vol. 8, no. 9, pp. 110–115, 2017.

[31] B. S. Jhorar, S. K. Varma, and R. P. Agarwal, "Effect of giberellic acid on the seedling emergence and early growth of cotton (*Gossypium hirsutum* L.)," *Indian Journal of Plant Physiology*, vol. 115, no. 4, pp. 423–426, 1982.

[32] R. K. Sinha, "Modern plant physiology," *Alpha Science International Ltd*, vol. 2, no. 2, pp. 21-22, Oxford, 2014.

[33] A. Lamichhane, M. Kc, M. Shrestha, and B. Baral, "Manisha shrestha and binaya baral, "effect of seed priming on germination of okra (*Abelmoschus esculentus var. Arka anamika*)," *Malaysian Journal of Sustainable Agriculture*, vol. 5, no. 2, pp. 111–114, 2021.

[34] J. P. Kumar, A. K. Chaurasia, and M. B. Bara, "Effect of organic priming on germination and vigour of cotton (*Gossypium hirsutum* L.) seed," *Journal of Agriculture Research and Technology*, vol. 9, no. 1, pp. 1–5, 2017.

[35] K. Sanodiya, G. Pandey, S. P. Rajput, and K. A Verma, "Effect of seed treatment with growth regulators on growth, yield and seed quality parameters of okra (*Abelmoschus esculentus* L.)," *International Journal of Chemical Studies*, vol. 5, no. 5, pp. 2301–2304, 2017.

[36] M. Sedghi, A. Nemati, and B. Esmaielpour, "Effect of seed priming on germination and seedling growth of two medicinal plants under salinity," *Emirates Journal of Food and Agriculture*, vol. 22, no. 2, pp. 130–139, 2010.

[37] S. Choudhary, M. Kushwaha, S. Preeti Singh, R. S. Sunil Kumar, and S. Kumar, "Cow urine a boon for sustainable agriculture," *International Journal of Current Microbiology and Applied Sciences*, vol. 6, no. 2, pp. 1824–1829, 2017.

[38] H. Kaura, N. Chawla, and M. Pathak, "Effect of different seed priming treatments and priming durations on biochemical parameters and agronomic characters of okra (*Abelmoschus esculentus* L.)," *International Journal of Plant Physiology and Biochemistry*, vol. 7, no. 1, pp. 1–11, 2015.

[39] D. B. Egli, D. M. TeKrony, and R. A. Wiralaga, "Effect of soybean seed vigor and size on seedling growth," *Journal of Seed technology*, vol. 14, no. 1, pp. 1–12, 1990.

[40] L. A. Ebone, A. Caverzan, A. Tagliari, J. L. T. Chiomento, D. C. Silveira, and G. Chavarria, "Soybean seed vigor: uniformity and growth as key factors to improve yield," *Agronomy*, vol. 10, no. 4, p. 545, 2020.

[41] TR. Wheeler and RH. Ellis, "Seed quality and seedling emergence in onion (*Allium cepa* L.)," *Journal of Horticultural Science*, vol. 67, no. 3, pp. 319–332, 1992.

[42] KJ. Bradford, AM. Tarquis, and J. M. . Durán, "A population-based threshold model describing the relationship between germination rates and seed deterioration," *Journal of Experimental Botany*, vol. 44, no. 7, pp. 1225–1234, 1993.