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SEED VIABILITY, GROWTH AND YIELD RESPONSES OF TWO OKRA (*ABELMOSCHUS ESCULENTUS* L.) VARIETIES TO DIFFERENT HYDRO-PRIMING DURATIONS

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ABSTRACT

Okra is a highly nutritious vegetable crop that has the potential to contribute to combating malnutrition in developing countries. However, dormancy due to hard seed coat is a major setback in the production of the crop. This study determined the influence of different hydro-priming durations on the seed viability growth and yield of Asontem and OH-152 Syngenta okra varieties. A 2x3 factorial experiment arranged in Randomized Complete Block Design (RCRD) with three replications was conducted. Factor one was variety at two levels (Asontem and OH-152 Syngenta), and factor two was hydro-priming durations at three levels (0, 12, and 24 hours). The study revealed that OH-152 Syngenta which was primed for 12 hours produced the most vigorous seedlings. The interaction of the OH-25 Syngenta variety with priming for 12 hours also led to early flowering compared with the other treatments. The interaction of priming durations and variety did not significantly affect the number of leaves the different weeks of data collection. However, the OH-152 Syngenta variety, which was primed for 12 hours produced more fruits and also gave higher yield as compared to the other treatments. Therewere strong, positive and significant relationships between germination percentage and vigour index (r=0.85), number of fruits (r=0.80) as well as number of leaves (r=0.89). Again, there was a strong, positive and significant relationship between vigour index and number of fruits (r=0.93) and weight of fruits (r=0.73). The linear regression analysis also showed that the number of fruits significantly affected the fruit weight such that 80% of the variation in the fruit weight was explained by the number of fruits. Furthermore, the vigour index significantly affected the number of fruits such that 87% of the variation in the number of fruits was attributed to the high vigour index. In conclusion, seeds of OH-152 Syngenta should be primed for 12 hours to improve seed viability growth and yield of the okra variety.

Keywords: Dormancy, physiological, embryo, radicle, emergence, cell division.

INTRODUCTION

Okra (*Abelmoschus esculentus* L.) is a vegetable, belonging to the Malvaceae family which is cultivated in many regions of the world (Zhang *et al.,* 2). The pods have high nutritional value and are rich in flavonoids and polysaccharides. The pods also have anticancer properties and are high antioxidants (Liao *et al.,* 2019; Deng *et al.,* 2020). The cultivation of this vegetable is common in the semi-arid regions, because it is a rustic crop with tolerance to high temperatures (Abubaker *et al.,* 2014). Flour obtained from okra has huge potential to be used in food fortification in order to provide adequate nutrition for daily needs (Adelakun and Oyelade, 2011). It contains fibre which can be used in rope making and in the paper industries. Okra seed oil is used as food and for biodiesel production (Anwar *et al.*, 2009).

Slow and poor germination of okra seeds have been found to be a problem faced by farmers and this is due to the hard seed coat (Felipe *et al.*, 2010). Studies have shown that poor germination of okra seeds result in low fertilizer efficiency, mistimed harvesting and reduced crop output (Rahman *et al.*, 2013). Priming of seeds before planting is a technique that has been found to improve the germination performance of most crops under controlled and uncontrolled conditions (Farooq, 2006). Seed priming is defined as a pre-sowing treatment that partially hydrates seeds without allowing emergence (Chen and Arora, 2013). Pre-sowing treatments often involve soaking the seeds in pre-determined amounts of water, called hydro-priming. Control of the imbibition rate by osmotic agents such as polyethylene glycol (PEG) is referred to as osmo-priming. Similarly, the use of specific salts for priming is called halo-priming, and the use of plant growth regulators for priming is known as hormo-priming (Lutts *et al.*, 2016). Soaking seeds in water for a period of time before planting (hydro-priming) is a method which ensures fast germination, improves seed growth and uniform crop establishment in many crops (Adebisi *et al.,* 2013). Hydro-priming is reported to have improved seed viability, growth of seedlings, and higher yield in bitter gourd (Adhikari *et al.*, 2021) and also improved the quality parameters of wheat (Singh *et al.*, 2017). Sikhondze and Ossom (2011) reported that pre-sowing treatment of okra seeds improves seedling growth. Different agronomic properties of okra such as the number of days taken to 50% flowering, seedling growth, fruit length, and total yield per plant increased as a result of hydro-priming (Kaur *et al.,* 2015). Additionally, Gilani *et al.* (2019), reported positive impact of pre-sowing treatments on seed germination and morphological growth of *Acacia nilotica* and *Faidherbia albida*. There is little research information on how hydro-priming durations influence the viability, growth and yield of the selected okra varieties. The objective of this study is to determine the influence of different hydro-priming durations on viability, growth and yield of hybrid and local varieties of okra.

MATERIALS AND METHODS

Description of Experimental Site

The experiment was carried out at the Department of Horticulture, Kwame Nkrumah University of Science and Technology, Ghana in plastic containers on an open field. The site has an elevation of 186 m above sea level with a bimodal rainfall pattern which is characteristic of the semideciduous forest zone. The major rains usually occur from late March to mid-July and a short dry spell from mid-July to mid-September. The minor rainy season also starts from mid-September to mid-November. The mean annual rainfall is about 1500 mm. The mean minimum and maximum temperatures for the area are 21°C and 31°C, respectively. The mean annual relative humidity is 95% in the morning and about 60% at noon during the major season. The soil at the experimental site is ferric Acrisol (Ablor, 1972).

Experimental design and procedures

The experiment was a 2 x 3 factorial arranged in a Randomized Complete Block Design (RCBD) with three blocks. Factor one was varieties at two levels (Asontem and OH-152 Syngenta) and factor two was hydro-priming durations at three levels (no priming, 12 hours and 24 hours). Seeds of both Asontem and OH-152 Syngenta were divided into 3 parts, with each part containing 54 seeds. The seeds were primed in distilled water for 12 and 24 hours while the control seeds were not subjected to priming. Topsoil was sieved and steam pasteurized and used to fill plastic buckets (40 cm diameter and 60 cm depth). Each bucket was filled with 10 kg of soil and provided with three drainage holes at the bottom. Thorough watering was done to allow the soil to settle prior to seed sowing. Subsequent watering was done at two days intervals. Stirring of soil was done periodically to ensure good aeration. Weeds were controlled by hand picking at two-week intervals. Golan (systemic insecticide) and Top Cop (fungicide) were applied at the rate of 50 ml per 15 l water and 100 ml per 15 l water respectively at two-week intervals against ladybird beetles, grasshoppers, crickets and podagricas.

Data collection

The number of days to 50% emergence was recorded by counting the days it took for seeds to attain 50% emergence (appearance of the radicle).

Germination percentage was determined by using the formula by (Maggio *et al.*, 2007) as shown below.

$$GP\% = \frac{number\ of\ germinated\ seeds}{number\ of\ viable\ seeds} \times 100\% \quad \textbf{eqn 1}$$

After 2 weeks of planting, a seedling from each bucket was uprooted and the hypocotyl and radicle length was measured, and the seed vigour index was calculated using the formula below (Abdul-Baki and Anderson, 1973).

$$\text{Seed vigour index (SVI)} = \frac{hypocotyl\ length + radicle\ length}{100} \times GP\% \quad \textbf{eqn 2}$$

Plant height: This was measured using a metre rule from the soil level to the tip of the shoot at two, four, six, eight and ten weeks after sowing

Stem diameter: Vernier calliper was used to measure the diameter of the stems at two, four, six, eight and ten weeks after sowing

Number of leaves: The number of leaves was counted and recorded at two, four, six, eight and ten weeks after sowing.

Days to 50% flowering: The number of days it took for 50% of the plants to flower was counted and recorded.

Number of fruits per plant: Fruit numbers in the various treatments were counted and recorded.

Fruit weight per plant: A digital scale was used to determine the weight of fruits in grams (g).

Data Analysis

Data collected was subjected to Analysis of Variance (ANOVA) using Statistix Software Version 10.0. ANOVA was used to determine whether there were significant differences among treatment means for the various parameters studied. For a proper comparison of the treatment means, Tukey's Honestly Significant Difference (HSD) was used at 5% profitability level.

RESULTS

Influence of hydro-priming durations on the number of days to germination of Asontem and OH-152 Syngenta okra varieties.

The interaction effect of priming durations and varieties on the number of days to emergence was significant at $p \leq 0.05$ (Table 1). The results show that the Asontem variety which was not primed took a longer time (5.67 days) to emerge while the priming of both varieties for 12 or 24 hours was the fastest to emerge at 4 days.

Table 1: Influence of hydro-priming durations on number of days to emergence of two okra varieties.

	Varieties of okra		
Hydro-priming durations (hrs)	Asontem	Hybrid (OH-152 Syngenta)	Means
0	5.67a*	4.00b	4.83a
12	4.00b	4.00b	4.00b
24	4.00b	4.00b	4.00b
Means	4.56a	4.00b	
HSD (0.05): varieties=0.248, priming durations=0.373, varieties*priming durations=0.667			

***Means with similar alphabets are not significantly (p≥0.05) different from each other.**

Influence of hydro-priming durations on percentage germination of Asontem and OH-152 Syngenta okra varieties.

There was statistical ($p \leq 0.05$) interaction differences between the priming durations and varieties for germination percentage (Table 2). The highest germination percentage (100%) was recorded when the hybrid variety was primed for 24 hours which was similar to the hybrid primed for 12 or without priming (0 hours).

Table 2: Germination percentage of Asontem and OH-152 Syngenta okra varieties as affected by hydro-priming durations.

	Varieties of okra		
Hydro-priming durations (hrs)	Asontem	Hybrid (OH-152 Syngenta)	Means
0	64.81ab	90.00a*	77.41a
12	68.52ab	100.00a	84.26a
24	53.70b	100.00a	74.08a
Means	62.35b	98.15a	
HSD (0.05): varieties=14.883, priming durations=22.436, varieties*priming durations=40.091			

***Means with similar alphabets are not different from each other significantly (p≥0.05).**

Influence of hydro-priming durations on the vigour index of Asontem and OH-152 Syngenta okra varieties

There was statistical ($p \leq 0.05$) interaction of priming durations and varieties for vigour index (Table 3). The highest vigour index was recorded when the Hybrid was primed for 12 hours (2370.3) and the least (1051.30) vigour index occurred when Asontem variety was primed for 24 hours.

Table 3: Influence of hydro-priming durations on vigour index of Asontem and OH-152 Syngenta okra varieties

	Varieties of okra		
Hydro-priming durations (hrs)	Asontem	Hybrid (OH-152 Syngenta)	Means
0	2017.3ab*	2226.3ab	2193.8a
12	1580.2bc	2370.3a	1975.3ab
24	1051.3c	2031.9ab	1541.6b
Means	1549.6b	2209.5a	
HSD (0.05): varieties=257.22, priming durations=387.77, varieties*priming durations=692.92			

***Means with similar alphabets are not different from each other significantly (p≥0.05).**

Influence of hydro-priming durations on stem diameter of Asontem and OH-152 Syngenta okra varieties

No significant ($p \geq 0.05$) variations existed between the interaction of priming durations and varieties for stem diameter at two, six and eight weeks after sowing (Figure 1). However, there was significant ($p \leq 0.05$) interaction between priming duration and varieties for stem diameter at week four. Asontem variety which was not primed had the greatest stem diameter (0.82 cm) and the least (0.53 cm) was in the hybrid variety which was primed for 12 hours. There existed statistical ($p \leq 0.05$) differences between the interaction of priming durations and varieties for stem diameter at week ten. Asontem variety which was not primed recorded the highest stem diameter (1.62 cm) and the least (1.20 cm) was hybrid variety which was primed for 12 hours.

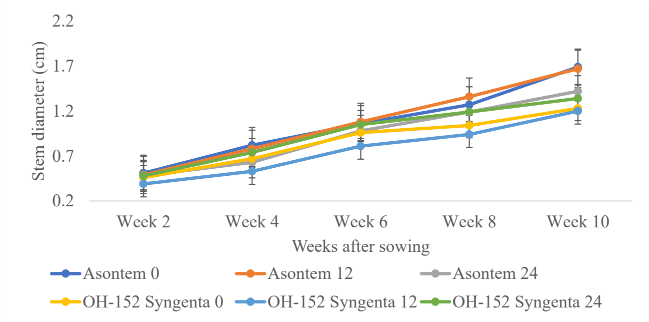

Figure 1: Influence of hydro-priming durations on stem diameter (cm) of Asontem and OH-152 Syngenta okra varieties at 2-10 weeks after sowing.

Influence of hydro-priming durations on the number of leaves of Asontem and OH-152 Syngenta okra varieties

No significant (p≥0.05) variations existed between the interaction of priming durations and varieties for the number of leaves at weeks two, six and eight (Figure 2). However, there was a significant (p ≤ 0.05) interaction effect of priming durations and varieties on a number of leaves at week four. Asontem variety which was not primed recorded the highest number of leaves (7.33) and the least (6.00) was recorded in both varieties when they were primed for 12 hours. Moreover, there was a significant (p ≤ 0.05) interaction effect of priming durations and varieties for a number of leaves at week ten.The Asontenm variety which was not primed gave the highest number of leaves (8.00) and was similar to Asontem which was primed for 12 and 24 hours. The hybrid variety which was primed for 12 hours gave the least number of leaves (5.67).

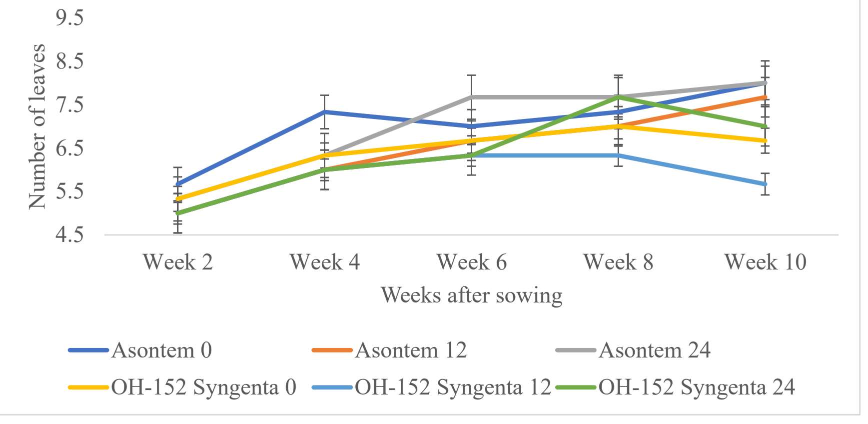

Figure 2: Influence of hydro-priming durations on the number of leaves of Asontem and OH-152 Syngenta okra varieties at 2-10 weeks after sowing.

Influence of hydro-priming durations on plant height of Asontem and OH-152 Syngenta okra varieties at two weeks after sowing

No significant (p≥0.05) variations existed between the interaction of priming durations and varieties for plant height at weeks two, four and six (Figure 3). However, there existed statistical (p ≤ 0.05) differences between the interaction of priming durations and varieties for plant height at week eight (Table 17). The Asontem variety which was not primed recorded the tallest plants (68.10 cm) and the shortest was the hybrid variety which was primed for 0, 12 and 24 hours. There existed statistical (p ≤ 0.05) differences between the interaction of priming durations and varieties for plant height at week ten (Table 18).The Asontem variety which was not primed had the tallest plants (101.13 cm) and the shortest was the hybrid variety which was primed for 0, 12 and 24 hours.

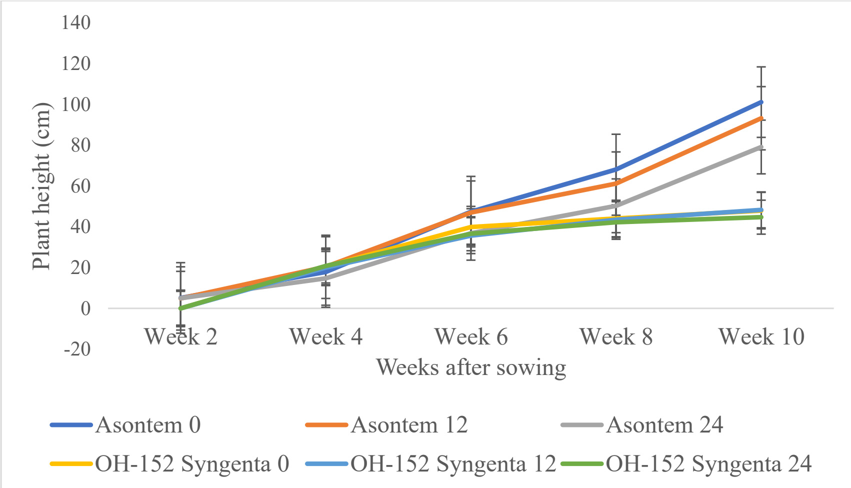

Figure 3: Influence of hydro-priming durations on plant height (cm) of Asontem and OH-152 Syngenta okra varieties at 2-10 weeks after sowing.

Influence of hydro-priming durations on the number of days to 50 % flowering of Asontem and OH-152 Syngenta okra varieties

There was a significant ($p \leq 0.05$) interaction effect between the priming durations and varieties for a number of days to 50% flowering (Table 4). The Asontem variety primed for 12 hours took more days (68.10) to attain 50% flowering while the hybrid variety not primed or primed for 12 or 24 hours took fewer days (38 days) to attain 50% flowering.

Table 4: Influence of hydro-priming durations on 50% flowering of Asontem and OH-152 Syngenta okra varieties

	Varieties of okra		
Hydro-priming durations (hrs)	Asontem	Hybrid (OH-152 Syngenta)	Means
0	46.33b*	38.00c	42.17b
12	47.00ab	38.00c	42.50ab
24	49.67a	38.67c	44.17a
Means	47.67a	38.22b	
HSD (0.05): varieties=7.891, priming durations=1.501, varieties*priming durations=8.432			

***Means with similar alphabets are not different from each other significantly (p≥0.05).**

Influence of hydro-priming durations on the number of fruits per plant of Asontem and OH-152 Syngenta okra varieties

There were statistical (p ≤ 0.05) differences between the interaction of priming durations and varieties for number of fruits (Table 5). The OH-152 Syngenta hybrid variety which was not primed had the highest number of fruits (32) and the least was obtained when the Asontem variety was primed for 24 hours

Table 5: Influence of hydro-priming durations on the number of fruits per plant of Asontem and OH-152 Syngenta okra varieties

	Varieties of okra		
Hydro-priming durations (hrs)	Asontem	Hybrid (OH-152 Syngenta)	Means
0	33.00ab*	32.33a	32.65a
12	30.00ab	37.33ab	33.67a
24	25.33b	35.00ab	30.17a
Means	29.44b	34.89a	
HSD (0.05): varieties=4.500, priming durations=7.00, varieties*priming durations=12.524			

***Means with similar alphabets are not different from each other significantly (p≥0.05).**

Influence of hydro-priming durations on fruit weight per plant of Asontem and OH-152 Syngenta okra varieties

There were statistical (p ≤ 0.05) differences between the interaction of priming durations and varieties for fruit weight (Table 6). The OH-152 Syngenta hybrid variety primed for 12 hours recorded the highest fruit yield (331.3 g) and the least was the Asontem variety primed for 24 hours.

Table 6: Influence of hydro-priming durations on the weight of fruits per plant (g) of Asontem and OH-152 Syngenta okra varieties

	Varieties of okra		
Hydro-priming durations (hrs)	Asontem	Hybrid (OH-152 Syngenta)	Means
0	289.05b*	214.71d	251.87a
12	213.12d	331.13a	272.13b
24	177.82e	224.84c	201.33c
Means	226.60b	256.89a	
HSD (0.05): varieties=25.432, priming durations=45.201, varieties*priming durations=148.121			

***Means with similar alphabets are not different from each other significantly (p≥0.05).**

Correlation analysis among some parameters

Table 7 depicts the correlation relationship among some of the parameters. There was a strong, positive and significant relationship between germination percentage and vigour index (r=0.86), number of fruits (r=0.80) as well as number of leaves (r=0.89). Additionally, there was a strong, positive and significant relationship between the vigour index and the number of fruits (r=0.93) and also with the weight of fruits (r=0.73).

Table 7: Correlation relationship among some of the parameters

	Germination Percentage	Vigour Index	Number of Fruits	Number of Leaves	Weight of Fruits
Germination Percentage					
Vigour Index	0.85				
Number of Fruits	0.80	0.93			
Number of Leaves	0.89	0.01	0.02		
Weight of Fruits	0.01	0.73	0.01	0.01	

Regression among some parameters

A linear regression model showed that the number of fruits significantly affected fruit weight such that 80% of the variation in the fruit weight was explained by the number of fruits (Equation 3).

$$Y_{(\text{number of fruits})}=-1635.53+109.329_{(\text{Vigour index})} \quad \textbf{Eqn 3}$$

$$R^2=0.8739,\ P=0.0062,\ N=6$$

Again, the vigour index significantly affected the number of fruits such that 87% of the variation in the number of fruits could be attributed to the vigour index Equation 3).

$$Y_{(\text{weight})}=18.0112+109.329_{(\text{number of fruits})} \quad \textbf{Eqn 4}$$

$$R^2=0.7989,\ P=0.049,\ N=6$$

DISCUSSION

Results of this study indicated that Asontem seeds that were not primed before sowing had the highest number of days to emergence, suggesting that priming durations reduced the number of days to emergence. Adebisi *et al.* (2013) reported that soaking seeds in water for a period of time ensured rapid germination. During germination, seeds imbibe water that causes the seed coat to rupture and allows the radicle to emerge easily. Seed coat softening and the facilitation of biological processes for early germination are mainly due to moisture absorption (Nawaz *et al.* 2013). Moreover, hydropriming also caused a reduction in the variations that existed at the initial stage of water imbibition, resulting in a more uniform germination (Galhaut *et al*. 2014). Armin *et al.*, (2010) have stated that seed priming leads to the softening of the seed coat and thereby reduces the restrictions to radicle emergence through the seed coat.

Seed emergence and performance of okra plants are affected by different seed priming treatments (Arif *et al.*, 2008). In the current study, seeds of the Asontem and Hybrid varieties that were primed in water for 24 hours had the lowest germination percentage. This decrease in germination percentage may be due to elevated levels of carbon dioxide, ethanol and lactic acids in the seeds which reduced the concentration of oxygen leading to poor germination. Seeds require optimum moisture to initiate germination but prolonged exposure to excess water has an adverse effect on the germination of many seeds. This could lead to injury caused by imbibition which occurs when seeds absorb water too rapidly, especially when the moisture content of the seed is low. Seeds damaged by imbibition injury have a low germination rate (Thornton *et al.*, 1990), a high percentage of abnormal seedlings (Toledo *et al.*, 2010), and increased solute leakage (Salim and Shereena, 2006). Our results corroborate their findings.

Mangena (2021) defined seed vigour as seed properties with the potential for rapid, uniform emergence and development of healthy and vigorous quality seedlings. Our results showed that seeds that were not primed had the highest vigour index and seeds primed for 24 hours had the least. This important seed quality property is a measure of the germination capacity at one particular point in time. This suggests that higher germination rates have a direct influence on the vigour. Our results agree with the previous findings of Kaur *et al.* (2015), who opined that pre-sowing treatment induces different activities of metabolism in the seed embryo and increases the shoot length and root length of seedlings.

The time of flowering has a direct impact on the stage of maturity of a crop (Craufurd and Wheeler, 2009). Early flowering will ultimately lead to early fruiting which was expected based on the results of the current study where the Asontem seeds primed for 12 and 24 hours germinated earlier than those that were not. The results of the current study agree with Murungu *et al.*, (2004) who reported that priming reduces the days to flowering and edible maturity of crops.

Zannat *et al*. (2023) reported that the fruit diameter, number of fruits per plant, and fruit weight are important traits that could be used to select for higher fruit yield to improve tomato productivity in breeding programs. In the current study, our results showed that Hybrid (OH-152 Syngenta) had the greatest number of fruits and Asontem recorded the least fruit numbers and this could be due to the variations in the genetic make-up of the two varieties. Hybrid crops always outperform open-pollinated varieties because they were bred by using two superior parents leading to a phenomenon known as heterosis.

CONCLUSION

The study revealed that the interaction of priming durations and variety did not significantly affect the number of leaves at the different weeks data were taken. However, the OH-152 Syngenta variety which was also not primed had an outstanding number of fruits and total fruit weight as compared to the other treatments. There were strong, positive and significant relationships between germination percentage and vigour index (r=0.85), number of fruits (r=0.80) as well as number of leaves (r=0.89). Again, there was a strong, positive and significant relationship between vigour index and number of fruits (r=0.93) and weight of fruits (r=0.73). A linear regression model showed that the number of fruits significantly affected fruit weight such that 80% of the variation in the fruit weight was explained by the number of fruits. Furthermore, the vigour index significantly affected the number of fruits such that 87% of the variation in the number of fruits was attributed to the vigour index. Seeds of OH-152 Syngenta should be primed for 12 hours to improve seed viability growth and yield of the okra variety.

Conflict of Interest

The authors declare that they have no conflicts of interest.

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