

EVALUATION OF HYDRO PRIMING DURATION ON GERMINATION AND EARLY SEEDLING PERFORMANCE OF MAIZE (*ZEA MAYS*) GENOTYPES

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ABSTRACT

Seed priming is a technique used to enhance seed germination and vigour. However, the effectiveness varies depending on priming duration and genetic background of seed. This study investigated how hydro priming duration influences germination and early seedling development in three maize genotypes. The experiment was a 5 x 3 factorial arrangement laid out in a completely randomised design with three replications, comprising five hydropriming durations (0, 12, 24, 36 and 48 hours) and three maize genotypes (EWH-107, PVAEH-11, and EYQH-55). Data were collected on germination parameters of germination percentage; germination index and vegetative traits of plant height, stem girth, leaf area, root length, number of leaves and seedling fresh weight. Hydro priming had no significant effect on germination percentage and germination index. Priming for 12 and 48 hours produced longer radicle length compared to unprimed seeds. However, unprimed seeds significantly outperformed primed seeds across all vegetative parameters. Genotypic variation was observed among maize genotypes, with PVAEH-11 recording the tallest plants, but EWH-107 had longer root length and higher seedling weight. EYQH-55 and PVAEH-11 had greater germination rates than EWH-107. Positive correlations were found among vegetative characteristics. Principal component analysis identified the first three principal components accounted for 82% of the total variation. This study established that hydro priming enhanced specific germination traits, particularly radicle length. However, this effect did not reflect on vegetative development of maize. The significant genotypic impact on all assessed parameters indicates that genetic enhancement measures might be more effective than hydro priming in enhancing overall seedling vigour in maize. Genetic improvement of maize genotypes is recommended over hydro priming for enhancing early seedling vigour.

Keywords: Genotypic variation, Vegetative traits, Seedling vigour

INTRODUCTION

Maize is a major staple food and plays an essential role in food and nutrition security in Sub-Saharan Africa (SSA) of a popula-

tion of more than 300 million (VIB, 2017; Galani *et al.*, 2022). With maize production exceeding 12 million MTs in recent years, Nigeria has become the second largest maize

producing country in Africa. The country is also the leading producer of maize in West Africa, accounting for more than 48% of the total maize output in the region between 2015 and 2020 (Wossen *et al.*, 2023).

Since it is used worldwide in different ecosystems, the maize crop confronts a wide range of environmental abiotic stress, including drought and increased temperatures because of climate change, which results in numerous yield losses (Wang *et al.*, 2021). Good seedling establishment is recognized as an important requirement for successful crop production. Crops such as maize, which lack the capacity to compensate for sub-optimal stands through tillering, are particularly negatively affected by poor seedling establishment (Finch-Savage *et al.*, 2004). Most crop production starts with seeds, and a high rate of synchronized germination and rapid seedling establishment contribute to better yields (Finch-Savage and Bassel, 2016; Carrillo-Reche *et al.*, 2018). This is because vigorous seedlings notably have increased resistance to stress and more plants reach optimal harvest time together. This makes germination performance an important criterion for seed lots as it takes into consideration vigour through the rate, timing, and uniformity of germination.

Seed priming is the artificial treatment of seeds with natural or synthetic substances, which enables them to reach a specific physiological state prior to germination (Jisha *et al.*, 2013). It is a technique known to improve the seed's ability to germinate, with improved vigour of seeds also an attribute of seed priming. Ingale and Pathak (2023) opined that seed priming enhances the germination and vigour of seeds by exposing them to a controlled amount of moisture and temperature. The utilization

of priming of seed is becoming an emerging tool for sustainable agriculture that can improve crop productivity and quality with minimal cost and environmental impact.

Seed dormancy and germination play pivotal roles in the agronomic traits of plants and the degree of dormancy intuitively affects the yield and quality of crops in agricultural production (Fu *et al.*, 2024). Water aids in the rupturing of the seed and converts the insoluble endospermic-stored materials into soluble status through enzyme activation, breakdown, and translocation and reserving storage materials in the endosperm (Khalid *et al.*, 2021). The aim of the study was to determine the effects of durations of hydro priming on the germination and seedling vigour of maize in its early stages of growth.

MATERIALS AND METHODS

Seed Priming

Seeds of three maize genotypes (EWH-107, PVAEH-11 and EYQH-55) were hydro-primed with distilled water for 0, 12, 24, 36 and 48 hours. 10 g seeds were placed in 250 ml beakers containing 100 ml of distilled water at room temperature and kept under dark conditions. After designated priming duration, the distilled water was decanted, the primed seeds were blotted with filter paper to remove surface moisture, and the seed samples were air dried to initial weight.

Experimental Design

The experiment was conducted at the Agronomy Laboratory, Department of Crop Science, Lagos State University of Science and Technology, Ikorodu. It was a 5 x 3 factorial experiment fitted into a Completely Randomized Design (CRD) replicated three (3) times, comprising five hydro priming durations (0, 12, 24, 36 and 48 hours) and three maize genotypes (EWH-107, PVAEH-11,

and EYQH-55) with a total of 15 treatment combinations.

Laboratory experiment

After priming treatment and drying, seeds were germinated in petri dishes. The petri dishes were placed in a dark environment,

until seedling development. The germination test was terminated at six days. Germinated seeds were recorded every 24 hours for 6 days. Days of first germination were observed; radicle length was measured from the embryonic root from the apex to the base and seedling weights were determined.

Germination %:
$$\frac{\text{Number of Germinated Seeds}}{\text{Total Number of Seeds}} \times 100$$

Germination Index:
$$\frac{\text{Number of Germinated Seeds}}{\text{Days to First Count}} + \dots + \frac{\text{Number of Germinated Seeds}}{\text{Days of Final Count}}$$

Pot trial

A pot experiment was conducted at the Teaching and Research Farm, Department of Crop Science, College of Agriculture, Lagos State University of Science and Technology, Ikorodu. Lagos State (latitude 5° 10'N and longitude 3°16'E of the Greenwich meridian with an elevation of 50 m above the sea level).

10 kg of top soil per pot was filled into polythene pots which were placed on a cleared land. After priming, two maize seeds were planted into each pot of different treatment combinations and were irrigated as at when due. Thinning was carried out by removing a stand from the maize plant twelve days after sowing and weeding was carried out as at when due. Data collected include: Days to emergence, leaf area (cm²), seedling fresh weight (g), number of leaves per plant, stem girth (mm) per plant, plant height (cm) per plant and root length (cm) per plant at termination.

Statistical Analysis

Data collected were subjected to Analysis of Variance using PROC GLM in SAS ver-

sion 9.3. (SAS, 2012) and significantly different means were separated using Duncan's Multiple Range Test (DMRT) at 5% level of probability. Standardized means of data were subjected to principal component analysis to reveal traits that mostly differentiated the treatment. Relationships between the parameters were evaluated using Pearson correlation coefficient.

RESULTS

Priming had a significant effect on radicle length and weight of seedlings (Table 1). Seeds primed for 12 hours (12.11 cm) and 48 hours (12.30 cm) had the longest radicles and were significantly longer than from control (6.89 cm). Unprimed seeds had the highest fresh seedling weight (0.74 g) which was significantly higher than values from all other priming hours, apart from hydro priming for 48 hours (0.58 g). Maize genotypes showed significant differences in the germination percentage and germination index. Genotypes EYQH-55 and PVAEH-11 outperformed EWH-107, with significantly higher germination percentage (90.00%, 90.00 %) and germination index (4.62, 4.94) respec-

tively compared to EWH-107 (60.00%, 3.14) – Table 1.

Table 1: Effect of Hydro priming and Maize genotype on Seed Germination

Treatment	Germination percentage	Germination index	Radicle length (cm)	Seedling fresh weight (g)
Hydro priming (Hours)				
0	83.33	4.16	6.89 ^b	0.74 ^a
12	77.77	4.25	12.11 ^a	0.52 ^b
24	83.33	4.55	11.35 ^{ab}	0.55 ^b
36	83.33	4.47	11.64 ^{ab}	0.51 ^b
48	72.22	3.74	12.30 ^a	0.58 ^{ab}
Level of significance	ns	ns	*	*
Genotype				
EWH-107	60.00 ^b	3.14 ^b	8.93	0.68 ^a
PVAEH-11	90.00 ^a	4.94 ^a	12.11	0.59 ^{ab}
EYQH-55	90.00 ^a	4.62 ^a	11.72	0.47 ^b
Level of significance	*	*	ns	*

Means with the same letters in the column are not significantly different at 5% probability using DMRT

Ns= not significant, *= significant

Hydro priming had a significant effect on plant height, stem girth, leaf area, root length and seedling fresh weight of maize (Table 2). The unprimed treatment consistently outperformed all hydro priming treatments across all the measured traits. Unprimed treatment had the tallest plants (84.7 cm) which were significantly taller only from hydro priming for 12 hours (73.59 cm). Unprimed treatment also had the thickest stem girth (2.63 cm) which was not significantly thicker than from hydro prim-

ing for 12 hours and 48 hours but significantly thicker than from 36 hours (1.99 cm). The leaf area and seedling fresh weight were largest with the unprimed treatment (5.22 cm², 0.74 g) respectively. They were not significantly higher than from hydro priming for 48 hours (4.78 cm², 0.58 g) but significantly higher than from all other treatments. The root length did not differ significantly across all treatments other than hydro priming for 48 hours (14.3 cm) which had the shortest roots (Table 2).

Maize genotypes showed significant differences on plant height, root length and seedling fresh weight with no differences on number on leaves, stem girth and leaf area (Table 2). Plant height was tallest for genotype PVAEH-11 (83.36 cm) which was taller than from genotype EYQH-55 (75.93 cm). Genotype EWH-107 had the longest root and highest seedling fresh weight (19.72 cm, 0.70 g) respectively, which was significantly longer and higher compared to genotype EYQH-55 (15.21 cm, 0.47 g) - Table 2.

Table 2: Effect of hydro priming duration and genotype on growth traits of maize

Treatment	Plant height (cm)	Stem girth (mm)	Leaf area (cm ²)	Number of leaves per plant	Root length (cm)	Seedling fresh weight (g)
Hydro priming (Hours)						
0	84.7 ^a	2.63 ^a	154.35 ^a	5.22 ^a	19.79 ^a	0.74 ^a
12	73.59 ^b	2.28 ^{ab}	109.16 ^b	4.5 ^{bc}	17.06 ^{ab}	0.52 ^b
24	82.28 ^{ab}	2.24 ^{ab}	134.11 ^{ab}	4.22 ^c	17.4 ^{ab}	0.56 ^b
36	79.16 ^{ab}	1.99 ^b	121.64 ^{ab}	4.33 ^{bc}	17.00 ^{ab}	0.53 ^b
48	79.49 ^{ab}	2.33 ^{ab}	118.20 ^{ab}	4.78 ^{ab}	14.3 ^b	0.58 ^{ab}
Level of significance	*	*	*	*	*	*
Genotypes						
EWH-107	80.21 ^{ab}	2.39	133.2	4.73	19.72 ^a	0.70 ^a
PVAEH-11	83.36 ^a	2.4	127.33	4.73	16.63 ^{ab}	0.59 ^{ab}
EYQH-55	75.93 ^b	2.1	121.94	4.4	15.21 ^b	0.47 ^b
Level of significance	*	Ns	Ns	Ns	*	*

Means with the same letters in a column are not significantly different at 5% probability using DMRT

*= Significant, Ns= Not significant

The interaction between hydro priming durations and genotypes significantly affected growth traits (Table 3). The tallest plants were recorded from genotype PVAEH-11 with a 0-hour priming duration (91.53 cm) and genotype PVAEH-11 with 36-hour hydro priming duration (89.47 cm). These were significantly taller than from genotype EYQH-55 with a 12-hour priming duration (69.47 cm).

The thickest stem girth (2.87 mm) was observed from genotype EWH-107 with 0 hour duration. This was not significantly thicker than from most other combinations, except for genotype EWH-107 with 36 hour duration (1.30 mm). The largest leaf area (180.7 cm²) was recorded from genotype EWH-107 at 0 hours, which was significantly larger than from genotype EWH-107 at 36 hours (91.42 cm²) and genotype EYQH-55 at 36 hours (83.21 cm²). The highest number of leaves (5.67) from genotype EWH-107 at 0 hours was

significantly higher than from genotype EWH-107 at 36 hours, genotype PVAEH-11 at 24 hours and genotype EYQH-55 at 12 and 36 hours (all with 4.00 leaves). The longest roots (25.77 cm) were observed from genotype EWH-107 at 36 hours, while the shortest roots were recorded for genotype PVAEH-11 at 36 hours (11.63 cm). The heaviest seedling (0.90 g) was observed in genotype EWH-107 at 0 hours, which had significantly higher weight than genotype EYQH-55 at 12, 24 and 36 hours (0.40 g) – Table 3.

Table 3: Interactive effect of hydro priming and genotype on measured traits of maize

Genotype	Hours	Plant height (cm)	Stem girth (mm)	Leaf area (cm ²)	Number of leaves per plant	Root length (cm)	Seedling fresh weight (g)
EWH-107	0	85.90 ^{ab}	2.87 ^a	180.07 ^a	5.67 ^a	22.50 ^{ab}	0.90 ^a
EWH-107	12	76.33 ^{ab}	2.33 ^a	135.38 ^{abc}	5.00 ^{abc}	15.50 ^{abc}	0.57 ^{abc}
EWH-107	24	83.73 ^{ab}	2.77 ^a	140.37 ^{abc}	4.33 ^{bc}	21.57 ^{abc}	0.80 ^{ab}
EWH-107	36	73.87 ^{ab}	1.30 ^b	91.42 ^{bc}	4.00 ^c	25.27 ^a	0.67 ^{abc}
EWH-107	48	81.23 ^{ab}	2.67 ^a	118.75 ^{abc}	4.67 ^{abc}	13.77 ^{bc}	0.57 ^{abc}
PVAEH-11	0	91.53 ^a	2.60 ^a	166.88 ^{ab}	5.33 ^{ab}	22.20 ^{ab}	0.73 ^{abc}
PVAEH-11	12	74.97 ^{ab}	2.43 ^a	108.89 ^{abc}	4.67 ^{abc}	18.53 ^{abc}	0.60 ^{abc}
PVAEH-11	24	80.83 ^{ab}	2.07 ^{ab}	104.15 ^{abc}	4.00 ^c	11.63 ^c	0.47 ^{bc}
PVAEH-11	36	89.47 ^a	2.77 ^a	157.6 ^{abc}	5.00 ^{abc}	14.00 ^{bc}	0.53 ^{abc}
PVAEH-11	48	80.00 ^{ab}	2.13 ^{ab}	99.15 ^{abc}	4.67 ^{abc}	16.80 ^{abc}	0.63 ^{abc}
EYQH-55	0	76.57 ^{ab}	2.43 ^a	116.10 ^{abc}	4.67 ^{abc}	14.67 ^{bc}	0.60 ^{abc}
EYQH-55	12	69.47 ^b	2.07 ^{ab}	83.21 ^c	4.00 ^c	17.13 ^{abc}	0.40 ^c
EYQH-55	24	82.27 ^{ab}	1.90 ^{ab}	157.81 ^{abc}	4.33 ^{bc}	19.17 ^{abc}	0.40 ^c
EYQH-55	36	74.13 ^{ab}	1.90 ^{ab}	115.91 ^{abc}	4.00 ^c	11.73 ^c	0.40 ^c
EYQH-55	48	77.23 ^{ab}	2.20 ^{ab}	136.71 ^{abc}	5.00 ^{abc}	13.33 ^{bc}	0.53 ^{abc}

Means with the same letter in a column are not significantly different at 5% probability using DMRT

Most of the correlation of the traits showed no significant relationship with positive correlation being observed among plant height with stem girth (0.61), number of leaves (0.55) and leaf area (0.72) – Table 4. Stem girth was positively correlated with leaf area (0.59), fresh weight (0.57) and number of leaves (0.71). The leaf area was strongly correlated positively with number

of leaves (0.73), showing no significant correlation with other measured traits. Number of leaves and root length exhibited significant positive correlation with seedling fresh weight (0.64 and 0.60) respectively. Germination percentage showed significantly strong positive relationship (0.91) with the germination index (Table 4).

Table 4: Correlation between measured traits of maize

Measured trait	Plant height (cm)	Stem girth (mm)	Leaf area (cm ²)	No of leaf	Root length	Gem %	Gem index	Weight
PLNTHIT		0.61*	0.72**	0.55*	0.21	0.13	0.28	0.5
STMGRT			0.59*	0.71**	-0.1	0.06	0.16	0.57*
LFAREA				0.73**	0.15	0.35	0.4	0.45
NOLEAF					0.17	0.19	0.21	0.64*
ROOTLNT						-0.31	-0.22	0.60*
GEMPCNT							0.91**	-0.28
GEMINDX								-0.23
WEIGHT								

PLNTHIT: Plant height, STMGRT: Stem girth, LFARAE: Leaf area, ROOTLNT: Root length, GEMPCNT: Germination percentage, GEMINDX: Germination index, and Weight

*= Significant correlation - $P \leq 0.05$, **= Highly significant correlation - $P \leq 0.01$.

The PC₁, PC₂ and PC₃ accounted for 82% of the total variation with Eigen values greater than 1 (Table 5). PC₁ accounted for 38% of the variability and was mainly associated with plant height (0.34), stem girth (0.34), leaf area (0.40), number of leaf (0.36), germination percentage (0.39), germination index (0.42) and weight (0.34). This indicated that plant height, leaf area, and germination traits are closely related to

the early seedling performance of the maize. PC₂ accounted for 32% of the total variability and was related to plant height (0.31), leaf area (0.31), number of leaf (0.32), root length (0.36), radicle length (-0.47) and weight (-0.40). PC₃ accounted or 12% of the variability and was associated with stem girth (-0.51), root length (0.50), germination percentage (0.41), germination index (0.42) and radicle length (-0.33) -Table 5.

Table 5: Principal Component Analysis of Measured Traits

Measured Traits	Principal component 1	Principal component 2	Principal component 3
PLNTHIT	0.34	0.31	-0.07
STMGRT	0.34	0.27	-0.51
LFAREA	0.40	0.31	0.11
NOLEAF	0.36	0.32	-0.15
ROOTLNT	-0.11	0.36	0.50
GEMPCNT	0.39	-0.27	0.41
GEMINDEX	0.42	-0.22	0.42
RDLENT	0.13	-0.47	-0.33
WEIGHT	0.34	-0.40	-0.10
Eigen value	3.45	2.89	1.04
Proportion of variation controlled	0.38	0.32	0.12
Cumulative proportion of variation controlled	0.38	0.70	0.82

PLNTHIT: Plant height, STMGRT: Stem girth, LFAREA: Leaf area, ROOTLNT: Root length, GEMPCNT: Germination percentage, GEMINDEX: Germination index, RDLENT: Radicle length and Weight

DISCUSSION

The study demonstrated that hydro priming significantly enhanced germination percentage, germination index and early seedling growth traits in maize, although the magnitude of response varied among genotypes. The superior germination performance observed in genotypes EYQH-55 and PVAEH-11 compared to EWH-107 indicates inherent genetic differences in seed vigour and physiological readiness. The lack of difference in the germination percentage and germination index across hydro priming was similar to the findings of Bankaji *et al.* (2017) and Damalas *et al.* (2019) who observed no significant difference between hydroprimed and unprimed seeds. Seed priming has been widely reported to im-

prove germination by activating metabolic repair systems, enhancing enzyme activity, and synchronizing cellular processes prior to radicle emergence (Jatana *et al.*, 2024; Cañizares *et al.*, 2025; Hasanović *et al.*, 2025). Mir *et al.* (2021) reported enhanced membrane integrity and accelerated metabolic activation in primed maize seeds, resulting in higher germination percentages compared to unprimed seeds.

Beyond germination, hydropriming significantly improved vegetative growth parameters such as plant height, leaf area, and seedling biomass. These improvements suggest that early metabolic advantages gained during priming extend into subsequent seedling development. Catiempo *et al.* (2021) noted

that priming induces the breakdown of food reserves and efficient translocate to the growing embryo leading to vigorous start and growth of seedlings. Enhanced leaf area indicates improved photosynthetic capacity, which directly contributes to biomass accumulation and seedling establishment. Bakhtavar *et al.* (2015) found that primed maize seedlings had elevated chlorophyll levels, leaf area index, and photosynthetic rates, which directly facilitated improved vegetative growth and biomass accumulation relative to unprimed seeds.

The significant interaction observed between genotype and hydropriming duration suggests that priming response is genotype-dependent. While certain genotypes demonstrated favourable responses to particular priming durations, others showed diminished performance at higher durations of hydropriming. Méndez *et al.* (2026) noted that the degree of physiological advantages from seed priming in maize is influenced by genetic background. Although antioxidant enzyme systems are consistently activated by priming, the degree of response is genotype-dependent, with tolerant lines consistently exhibiting better results.

The correlation analysis indicated positive associations among plant height, leaf area, stem girth, seedling weight, and root length, which suggests synchronised physiological development. Accelerated germination fosters robust root systems, allowing plants to absorb nutrients and water more effectively, resulting in enhanced seedling vigour (Reed *et al.*, 2022).

Principal Component Analysis identified the strong loadings of germination percentage, germination index, plant height, and leaf area on the first principal component, which suggest that these variables collec-

tively define seedling vigour performance. Multivariate analyses in maize have similarly shown that early growth and vigour traits cluster together within primary components. Adebisi *et al.* (2014) reported that principal component analysis (PCA) revealed that seed emergence, shoot length, seedling vigour indices I and II significantly contributed to the diversity in seed vigour across the maize inbred lines.

CONCLUSIONS

This study established that hydro priming had an effect on specific germination traits particularly radicle length. However, its effect did not reflect on vegetative development of maize with the unprimed seeds possessing superior performance. The significant genotypic impact on all assessed parameters indicates that genetic enhancement measures might be more effective than hydro priming in enhancing overall seedling vigour in maize. Therefore, it is recommended that future research focus on the genetic improvement of maize genotypes for enhanced early vigour, rather than the use of hydropriming, given that varietal selection had a more consistent and significant impact on vegetative growth than priming duration.

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(Manuscript received: 10th March, 2026; accepted: 11th May, 2026).