



EFFECT OF SEED PRIMING ON GERMINATION AND SEEDLING GROWTH OF SORGHUM (*Sorghum bicolor* (L. MOENCH))

¹Lawal, A. A., ²Mangshin, G. B., ²Shuaibu, Y. M. and ²Kuwre, S.

¹Department of Agricultural Biotechnology, Federal College of Forestry, Jos, Nigeria.

²Department of Crop Production, Abubakar Tafawa Balewa University, Bauchi, Nigeria.

Corresponding Author's Email: biodunlawal07@gmail.com, **GSM:** 2348067670709

ABSTRACT

Seed emergence and germination are critical initial phases in the plant life cycle, during which the embryo successfully overcome dormancy, activate metabolic process, and stimulate early seedling establishment. Seed priming is a simple, low-cost pre-sowing technique used to enhance germination performance and early seedling vigor. The present study was carried out to investigate the effects of plant priming agents on germination, and seedling growth responses of sorghum seeds. The treatments consisted of soaking the seeds of sorghum in moringa leaf extract, aloe vera extract, coconut water extract, lemon grass and lime extract for 10hours. The result reveals that, priming with moringa leaf extract, aloe vera extract, coconut water extract and lemon grass increased final germination percentage, germination index, root length, shoot length and seedling fresh weight of both cultivars as compared to all pre sowing seed treatments including control. Seeds of sorghum cultivars primed with moringa leaf extract, aloe vera extract, coconut water extract and lemon grass, significantly reduced the time taken to 50% emergence and mean emergence, increased final seedling emergence percentage and seedling growth. Results also indicated that priming with varying plant aqueous extract improved germination potential and seedling establishment of the cultivars and it proved to be better option than control which resulted in poor emergence and seedling growth. The highest germination was recorded on seeds primed with moringa leaf extract with (93.33%) and is recommended for priming of sorghum seed.

Keywords: Sorghum, Extract, Priming, Germination, Vigor, Seed

INTRODUCTION

Plants are highly susceptible and sensitive to adverse environmental conditions during the seedling and early vegetative stages. Dembélé *et al.*, (2021) reported that, Early-season drought limits crop germination. Climate change is characterized by increased in temperature and drought. Globally, climate change negatively impacts agricultural productivity by reducing seed emergence, impairing germination, limiting plant growth, and ultimately diminishing both the quantity and quality of harvested crop yields. Among the crops affected by climate change, sorghum is an important crop for smallholder farmers (Niyibigira, 2012), who lack the resources to adapt to the impacts of climate change (NBDF, 2014). Climate change induced high temperatures disrupt sorghum crop growth and development, causing reduced yield due to disturbances in cell division, metabolism, photosynthesis, and nutrient uptake (Ndlovu *et al.*, 2021; Prasad *et al.*, 2021). As a result, Stresses at any stage of crop growth can cause an irreversible loss in yield potential (Pirasteh-Anosheh *et al.*, 2011; Hamidi and Pirasteh-Anosheh, 2013).

Seed germination is affected by adverse environmental conditions including salinity, high temperature, and drought (Wahid *et al.*, 2007). High temperature regimes due to climate change affect the percentage of seed germination, photosynthetic efficiency, crop phenology, reproductive biology, flowering times, pollen viability and pollinator populations (Kumaraswamy & Shetty, 2016; Antle and McGuckin, 1993). Good seedling establishment is an important prerequisite for successful crop production (Lamichhane *et al.*, 2019). Poor seed germination and establishment of crop plant remains significant constraints in achieving optimal crop performance, particularly under the increasingly unpredictable environmental conditions exacerbated by climate change. According to Koirala (2017), faster emergence, better and more uniform stands, less need to re-sow, more vigorous plants, earlier flowering, earlier harvest and higher and stable grain yield were the benefits of seed priming.



Seed priming is a simple, affordable pre-sowing method that improves seed performance and synchronizes germination in both stressful and non-stressed conditions by stimulating the physiological processes within the seed. Seed priming, a pre-sowing partial hydration treatment that activates early metabolic processes without radicle emergence, enhances germination rate and uniformity, reduces seedling emergence time, promotes seedling growth and development, regulates key physiological, biochemical, and molecular processes, improves nutrient uptake and stress tolerance, and ultimately contributes to higher crop yield (Ceritoglu *et al.*, 2024; Mondal *et al.*, 2022; Mustafa *et al.*, 2017; Dastanpoor *et al.*, 2013). It entails the partial germination of seed by soaking in either water or in a solution for a specified period of time and then re-drying them just before the radicle emerges (Neto and Tabosa, 2000). Priming is a useful tool for improving the quality of seedlings (Mavi *et al.*, 2011). Seed priming stimulates many of the metabolic processes involved in the early germination phases and it has been noted that seedlings from primed seeds appear faster, grow more vigorously and perform better under adverse conditions (Chavan *et al.*, 2014). However, priming techniques, environment, and genotypes (seed coat), priming solution composition and Osmotic potential affect priming efficiency.

Many literatures reported that, Botanical plants contain growth regulatory properties that will enhance germination and good establishment of seedlings (Imran *et al.*, 2014). According to Foidl *et al.* (2001), moringa leaf is also rich in ascorbates, carotenoids, phenols, potassium and calcium, which have plant growth promoting capabilities and often applied as an exogenous plant growth enhancer. Among the different natural sources used, extracts of plants and their endogenous growth regulators such as coconut water are gaining lots of attraction (Foidl *et al.*, 2001). Coconut water with its several hormones may facilitate the germination rate of seedlings (Overbeek *et al.*, 2001). For instance, Dada *et al.*, (2019) reported high percentage emergence of *Annona muricata* seeds with increase in the time of soaking in coconut water.

Sorghum is the fifth most important cereal crop in the world after rice, wheat, corn and barley and it serves as the main cereal food for over 750 million people living in semi-arid tropical regions of Africa, Asia and Latin America (Codex Committee on Contaminants in Foods, 2011). Sorghum holds a crucial position in global food security due to its versatile usage as a staple food, bioenergy source, feed for livestock, and industrial products (Habyarimana *et al.*, 2020). sorghum not only pertains to ensuring food security but also plays a compelling role in fostering sustainable agricultural practices and stimulating rural development (Arouna, 2020). It is one of the principal sources of energy, protein, vitamins, and minerals for millions of the poorest people in the semi-arid region (Stefoska-Needham *et al.*, 2015).

Despite the potential benefits of plant extract seed priming, the mechanistic basis of individual phytochemicals remains poorly understood. The soaking duration and redrying procedures are also not standardized. Most of the result on plant extract priming are always from greenhouse, there is a need for field validation. Also, the impact of priming on the seed and soil microbiome is also unknown. Farmers need locally available priming agent or techniques that are both economically inexpensive and environmentally friendly, to overcome the problem of low seedling establishment in Nigeria. Hence, this experiment seeks to examine the priming effects of plant extracts on Sorghum in enhancing germination and initial seedling growth performance under controlled conditions in Jos, Plateau, Nigeria.

MATERIALS AND METHODS

Study Area

The study was conducted at the screen house of the Federal College of Forestry (latitude 09055'N, Longitude 08053'E and altitude 1,217m above sea level), located at the Jos-North, Plateau State, during rainy season of 2020. The experimental station is located within the Northern Guinea Savanna ecological zone of Nigeria (Kowal and Knabe, 1972). The experiment was laid out in completely randomized design (CRD).



Source of Experimental Seeds

Sorghum seed variety named CSR 01 was gotten from International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Kano, Nigeria. It is an open pollinated seed variety. The variety is locally known as “farafara”.

Treatment Details

The seed was treated with different plant extracts (Coconut water aqueous extract, Moringa leave aqueous extract, Lime aqueous extract and Lemon grass leaves aqueous extract) as the priming agents and control. Fresh Moringa leaves, and Aloe vera were obtained from a mature moringa tree at Agricultural Development Program, Rikkos, Jos-North local Government and its’ juices was extracted by a locally fabricated juice extraction machine following the method of the foidlet al., (2001), lemon grass leaves were obtained in the College following the same method as the above, while matured coconut fruit, lime oranges were purchased from Terminus Market and its water was harvested in the chemistry laboratory of the College. All the plant materials were taken to herbarium for identification. The plant materials were washed thoroughly and extraction was done with local machine. These concentrates were kept for 48 hours. After 48 hours the extracts were filtered by two layer of muslin cloth to remove unwanted material and leaf debris. The concentrations were mixed with distill water in ratio 2:1 to form their respective solutions.

The seeds were soaked in their respective solution for 10 hours. After each treatment, seeds were given three surface washings with distilled water and later dried closer to its’ original moisture at room temperature. Five seeds from each of the treatments was sown in pots having soil mixture of top soil, sand and poultry dropping all in ratio 1:1:1.

Method of Data Collection

The germination data was collected for the first 14 days after planting. At 20 days after planting, the following growth parameters were collected: Seedling length, Shoot diameter (mm), Seedling root length, Seedling Dry Weight, Seedling fresh Weight

Daily observation for germination of seedling was done for 14 days after sowing. The seedlings were evaluated as described in Seedling Evaluation Handbook (AOSA, 1991) till a constant count is achieved. Mean germination time (MET) was calculated according to the equation of Ellis and Roberts (1981). Germination energy was measured at 4th day of planting. It is the percentage of germinated seeds at 4th day of planting to the total number of tested seeds (Ruan *et al.*, 2002).

Germination percentage was measured by using the following formula.

$$GP = \frac{\text{No of seeds germinated} \times 100}{\text{Total no of seeds sown}}$$

Germination index (GI) was estimated according to the rules of Association of official Seed Analysts (AOSA) (Anonymous. 1983) by using the following formula.

(Germination index = number of germinated seeds/ Days of first count + -----+ number of germinated seeds/Days of final count)

Mean Germination Time (MGT) was calculated using the formula of Ellis and Roberts (1981):

$$MGT = \frac{\sum Dn}{\sum n}$$

Seedling length (cm): The seedling length was measured from ground level to the tip of the main stem at 20 days, 25 days and 30 days after sowing. The length obtained from three plants was computed and expressed in centimeters

Data Analysis

The data was statistically analyzed using analysis of variance (ANOVA) procedure for combined analysis. Means were separated using least significant difference LSD test at 0.05 level of probability (Steel & Torrie, 1984). Statistical Package for the Social Sciences (SPSS), version 27.

RESULT

Effect of Priming Sorghum Seed with Plant Extracts on Germination %

Table 1 shows the effect of different priming agents on germination percentage of sorghum seed. The main effect of priming agents were not significant ($P \leq 0.05$) on germination percentage of



sorghum bicolor seeds. However, the result shows that the highest mean value occurred in T₃ (Moringa leaf extract) with a mean value of 93.33, followed by treatment T₂(Aloe vera extract) with a mean value of 86.67. Treatment T₆ (control) gave the lowest germination percentage among the different treatments with mean value of 66.67.

Table 1: Effects of Different Priming Agents on the Mean Germination % of Sorghum Seed

Treatments	Germination %
T ₁	73.33
T ₂	86.67
T ₃	93.33
T ₄	80.00
T ₅	73.33
T ₆	66.67
SE±	12.77
L.S	N.S

T₁: coconut water extract, T₂: Aloe vera, T₃: Moringa leaf extract, T₄: Lime orange extract, T₅: Lemongrass, T₆: control.

N.S: Not Significantly

S.E: Standard Error

L.S: level of Significant

Effect of Priming Sorghum Seed with Plant Extracts on Germination Energy

The effect of different priming agents on germination energy of Sorghum seed is as shown in table 2. The result shows that no significant difference occurred in the different priming agents on the germination energy of sorghum bicolor at $p \leq 0.05$ level of significance. However, T₃ and T₅ gave the highest mean value (66.67), followed by T₁ with a mean value of (60.00). The lowest mean value occurred in T₂ and T₆ that gave a mean value of 53.33 and 53.33 respectively.

Table 2: Effects of Different Priming Agents on the Germination Energy of Sorghum Seed

Treatments	Germination Energy
T ₁	60.00
T ₂	53.33
T ₃	66.67
T ₄	53.33
T ₅	66.67
T ₆	53.33
SE±	15.86
L.S	N.S

T₁: coconut water extract, T₂: Aloe vera, T₃: Moringa leaf extract, T₄: Lime orange extract, T₅: Lemongrass, T₆: control.

N.S: Not Significantly

S.E: Standard Error

L.S: level of Significant

Effect of Priming Sorghum Seed with Plant Extracts on Germination Rate Index

The effect of plant extract priming agents on Sorghum seed is as shown in table 3. The result shows that no significant difference occurred in among the priming agents on the germination percentage of sorghum. However, T₆ (control) gave the highest mean value (35.32), followed by T₄ with a mean value of (32.42). The lowest mean value occurred in Moringa leaf extract that gave a mean value of 24.43.



Table 3: Effects of Different Priming Agents on the Germination rate index of Sorghum seed
 Mean Germination Rate Index

Treatment	GRI
T ₁	32.07
T ₂	31.23
T ₃	24.43
T ₄	32.42
T ₅	31.17
T ₆	35.32
S.E	5.09
L.S	N.S

T₁: coconut water extract, T₂: Aloe vera, T₃: Moringa leaf extract, T₄: Lime orange extract, T₅: Lemograss, T₆: control.
 N.S: Not Significantly
 S.E: Standard Error
 L.S: level of Significant

Effect of Priming Sorghum Seed with Plant Extracts on Root Length

Table 4 shows the effects of different priming agents on the root length of Sorghum seed. The result shows that significant differences occurred at $p \leq 0.05$ level of significant in the different priming agents used. Treatment T₂ (Aloe vera) gave maximum mean value of 2.10, followed by T₆ (control) with a mean value of 1.80. Treatment T₄ (lime extract) gave minimum mean value with a mean value of 1.10. Treatment T₂ is observed to be significantly different from T₁ and T₄, but it is seen to be statistically similar to treatment T₃ and T₆. Treatments T₁ (coconut water) and T₄ are also observed to be similar to treatments T₃ (Moringa leaf), T₅ (lemo grass) and T₆.

Table 4: Effects of different Priming Agents on the Mean Root Length of Sorghum seed

Treatments	Root Length(cm)
T ₁	1.18 ^a
T ₂	2.10 ^b
T ₃	1.47 ^{ab}
T ₄	1.10 ^a
T ₅	1.37 ^{ab}
T ₆	1.80 ^{ab}
SE±	0.34
L.S	*

T₁: coconut water extract, T₂: Aloe vera, T₃: Moringa leaf extract, T₄: Lime orange extract, T₅: Lemograss, T₆: control. Means followed by the same letters are not significantly different at P=0.05
 S.E: Standard Error
 L.S: level of Significant

Effect of Priming Sorghum Seed with Plant Extracts on Seedling Dry Weight

Table 5 shows the effects of different priming agents on dry weight of Sorghum seed. The result shows significant differences occurred in the different priming agents used. Treatment T₃ gave the highest mean value with a mean value of 0.27, followed by T₆ (0.22). Treatment T₄ gave the lowest mean value with a mean value of 0.03. Treatment T₃ is observed to be significantly different from T₆ and T₅, but they are seeing to be statistically similar. Treatments T₁ is also observed to be statistically similar to treatments T₂, and T₄. This could be as a result of improve cell elongation in T₃. Improved seedling dry weight due to priming might be attributed to increased cell division within the apical meristem of seedling roots, which cause an increase in plant growth and could also be due to physiological process and repair mechanism that occur during priming (Taylor and Harman, 1990).

Table 5: Effects of Different priming Agents on the Seedling dry Weight of Sorghum Seed

Treatments	Mean Seedling dry Weight (g)
T ₁	0.09 ^{ab}
T ₂	0.15 ^{bc}
T ₃	0.27 ^d
T ₄	0.03 ^a
T ₅	0.19 ^{cd}
T ₆	0.22 ^{cd}
SE±	0.034
L.S	*

T₁: coconut water extract, T₂: Aloe vera, T₃: Moringa leaf extract, T₄: Lime orange extract, T₅: Lemoglass, T₆: control.

Means followed by the same letters are not significantly different at P=0.05

S.E: Standard Error

L.S: level of Significant

Effect of Priming Sorghum Seed with Plant Extracts on Seedling Fresh Weight

Table 6 shows the effects of different priming agents on fresh weight of sorghum seed. The result shows significant differences occurred in the different priming agents used ($p \leq 0.05$). Treatment T₃ gave the highest mean value with a mean value of 0.34, followed by T₆ and T₅ (0.28). Treatment T₁ gave the lowest mean value with a mean value of 0.13. Treatment T₃ is observed to be significantly different from T₅ and T₆, but they are statistically similar. Treatments T₁ is also observed to be statistically similar to all other treatments except T₃.

Table 6: Effects of Different Priming Agents on the Mean Seedling Fresh Weight of Sorghum Seed

Treatments	Mean Seedling Fresh Weight (g)
T ₁	0.13 ^a
T ₂	0.21 ^{ab}
T ₃	0.34 ^b
T ₄	0.18 ^{ab}
T ₅	0.28 ^{ab}
T ₆	0.28 ^{ab}
SE±	0.05
L.S	*

T₁: coconut water extract, T₂: Aloe vera, T₃: Moringa leaf extract, T₄: Lime orange extract, T₅: Lemoglass, T₆: control.

Means followed by the same letters are not significantly different at P=0.05

S.E: Standard Error

L.S: level of Significant

Effect of Priming Sorghum Seed with Plant Extracts on Seedling Length

The impact of seed priming with different priming agents on seedling length is as displayed (Table 7). The result shows that significant differences were observed among the different treatments. Treatment T₆ is seen to be significantly different from T₅, and its also observed to be statistically similar to T₁, T₂, T₃ and T₄. Treatment T₅ is also seen to be statistically similar to T₁, T₂, T₃ and T₄. The highest mean value occurred in T₆ (20.33), followed by T₂ and T₃ (18.67 and 17.32) respectively.

Table 7: Effects of Different Priming Agents on the Mean Seedling Length of Sorghum Seed

Treatments	Mean Seedling Length (cm)
T ₁	17.33 ^{ab}
T ₂	18.67 ^{ab}
T ₃	17.32 ^{ab}
T ₄	16.37 ^{ab}
T ₅	15.30 ^a
T ₆	20.33 ^b
SE±	2.02
L.S	*

T₁: coconut water extract, T₂:Aloe vera, T₃:Moringa leaf extract, T₄:Lime orange extract, T₅:Lemograss, T₆: control.

Means followed by the same letters are not significantly different at P=0.05

S.E: Standard Error

L.S: level of Significant

Mean Germination Time (MGT)

Table 8 displays the result for the effects of different priming agents on the mean germination time of Sorghum seed. The result shows that no significant difference occurred in the mean of germination at $p \leq 0.05$. The highest mean value however occurred in treatment T₄ (9.75), followed by 9.38 as observed in T₂. No much differences were observed between the highest mean value and the lowest but as such, treatment T₅ gave the lowest mean value of 9.15 at $p \leq 0.05$ level of significant.

Table 8: Effects of Seed Priming on Mean Germination Time of Sorghum Seed

Treatments	Mean Germination Time (days)
T ₁	9.28
T ₂	9.38
T ₃	9.29
T ₄	9.75
T ₅	9.15
T ₆	9.28
SE±	0.41
L.S	N.S

T₁: coconut water extract, T₂: Aloe vera, T₃: Moringa leaf extract, T₄: Lime orange extract, T₅: Lemograss, T₆: control. N.S: Not Significantly S.E: Standard Error L. S: level of Significant

DISCUSSION

The essential phases in crop quality and development include uniform seed germination, seedling growth, and an even plant establishment (Waqas *et al.*, 2019). Seed priming is a physiological technique that involves the controlled hydration and dehydration of seeds to enhance pre-germinative metabolism for speedy germination (Dawood, 2018). In our study, seed germination and seedling growth increased with plant extract priming agents compare to unprimed. This could be due to the the presence of natural plant growth hormone like zeatin, cytokinin, auxin and gibberellin and other bioactive substance which regulate germination and growth that has been reported. The observations from our study indicate that the Moringa leaf extract has highest germination percentage with a mean value of 93.33, followed by treatment T₂ (Aloe vera extract) with a mean value of 86.67, compare to control (unprimed) with 66.67%. The result was seen not to be significant. However, the observed trends are consistent with reports that botanical extracts can enhance seed germination in cereals.

The result observation on root length, seedling dry weight and seedling fresh weight shows significant difference with most of the treatment have higher efficiency than the unprimed. This result is in accordance with the observation of (Sharma *et al.*, 2014) who observed that seed treatment with the coconut water solution led to a significant improvement in the germination rate, similar reports



were seen in the study of (Chuwang *et al.*, 2018) where seed priming with coconut water had the highest germination percentage. Kumar *et al.* (2021) also reported a positive effect on seed germination and plant growth of Chili pepper primed with 2% KNO₃. The observed trends, particularly the improved performance of Moringa and Aloe vera extracts, match with global evidence suggesting that plant-based priming agents increase seed germination and early vigour in sorghum and other crops.

In Nigerian sorghum production systems, particularly among smallholders, adopting Moringa or Aloe priming protocols provide a cost-efficient and environmentally sustainable approach to enhance stand establishment and resilience. Future research should concentrate on (1) standardising extract preparation and priming protocols for local varieties, (2) executing multi-location field trials to corroborate laboratory results across varied agroecologies, and (3) conducting genotype-specific screenings to identify sorghum lines that exhibit the highest responsiveness to botanical priming. Addressing these areas will enable the conversion of seed priming research into scalable agricultural techniques that enhance food security and climate resilience in Nigeria and abroad.

CONCLUSION AND RECOMMENDATION

Seed priming with plant extracts significantly improved the germination and seedling growth of sorghum. Moringa leaf extract proved most effective in germination percentage and seedling biomass, while Aloe vera, coconut water, and lemon grass extract also enhanced vigor compared with the control. Plant-based priming agents is an eco-friendly and low-cost approach for improving sorghum stand establishment.

Moringa leaf extract is recommended as the most effective seed priming agent for sorghum, while Aloe vera, coconut water, and lemon grass may serve as alternatives where moringa is unavailable. Adoption of these priming protocols, particularly in Nigerian smallholder systems, offers a cost-effective and environmentally friendly approach to enhance germination and crop resilience. Future research should focus on standardizing extract preparation, optimizing concentrations, and testing combinations for potential synergistic effects. Multi-location field trials and genotype-specific screenings are also advised to validate effectiveness and identify the most responsive sorghum varieties for large-scale adoption.

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