



## EFFECTS OF OSMO-PRIMING DURATION ON RICE (*ORYZA SATIVA* L.) SEED GERMINATION AND SEEDLING PARAMETERS

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### Abstract

The study was conducted to determine the effects of osmo-priming duration on the germination and seedling parameters of rice seeds. Two rice varieties FARO 44 and FARO 59 were used for the study. Three osmo-priming chemicals (Calcium chloride CaCl, Potassium nitrate KNO<sub>3</sub> and Polyethylene glycol PEG6000) and four priming duration's (Control, 12, 24 and 36 hours in the above chemical solutions) as treatments in the study. Data were collected on the following parameters; final germination percentage, germination rate index, mean germination time, coefficient of velocity of germination, seedling height, seedling fresh weight and seedling dry weight. For most of the parameters, osmo-priming duration was statistically significant. The results showed that chemical priming treatments had significant effect on final germination percentage, mean germination time, germination rate index, coefficient of velocity of germination, seedling height and seedling weight of rice seeds. Primed with KNO<sub>3</sub>, PEG6000 and CaCl solution for a period of 24 - 36 hours is a remarkable technique for improving seed germination and seedling growth of rice. The no priming treatment showed the lowest final germination percentage, mean germination time, germination rate index, coefficient of velocity of germination, seedling height and seedling weight of rice seeds. Therefore, the present study concludes that improvement of germination capacity and rapidity of germination of rice seed could be possible by employing osmo-priming duration treatments.

**Keywords:** rice, osmo-priming, duration, seed, germination, seedling, parameters

### Introduction

Rice (*Oryza sativa* L.) is a widely grown cereal crop and a staple meal for over half of the world's population, particularly in tropical Latin America and East, South, and Southeast Asia. It is cultivated in a variety of locales, covering around 11 % of the world's arable land (Seck et al. 2012). Paddy rice output in the globe totals 178 million tonnes, with Asia leading the way with 90.6 percent, followed by America with 5.2 percent, and Africa with 3.5 percent (FAOSTAT 2020). Rice output in Nigeria increased from 3.7 million metric tons in 2017 to 4.0 million metric tons in 2018. According to Kamai et al. (2020) the primary rice-producing states in Northern Nigeria are Kebbi, Borno, Kano, and Kaduna. Rice requires a lot of water for maximum germination, development, and output, drought is a severe barrier to rice production in Northern Nigeria (Kamai et al. 2020).

Direct seeded rice is an essential production strategy for resource-poor farmers in Sub-Saharan African (SSA) nations (Ampong 1996), and it is predicted to expand in importance with the



introduction and widespread acceptance of New Rice varieties with high yield potential and a short growth cycle (WARDA 2008). Direct seeding of rice in aerobic cultures has evolved as a resource-saving approach that eliminates the need for puddling in transplanted rice cultures, saving water, labor, and fuel (Liu 2014). Broadcasting without dibbling on wet soil has been a standard seeding strategy for rice sowing in West Africa, particularly Nigeria (Ampong 1996). Poor germination, on the other hand, has been one of the barriers to its acceptance in the field (Liu 2014). Uniformity, poor germination, and variable seedling emergence capabilities have a significant influence on eventual yield, quality, and, ultimately, revenues (Tzortzakis 2009). Priming is the process of immersing seeds in enough water to initiate pre-germinative metabolic activity while inhibiting radicle emergence. These seeds may be dried, and when imbibed, they will typically show faster radicle emergence and good seedling establishment (Heydecker et al. 1997). Rice uses a variety of seed priming strategies such as hydro-priming, osmo-priming, hormone priming, nutritional priming, and chemical priming (Farooq et al. 2009). Priming a rice crop gives it a strong head start, resulting in faster and more uniform emergence, greater stand establishment, and higher rice output (Farooq et al. 2009). These characteristics have significant agronomic significance, particularly in difficult germination settings (McDonald 2000). Osmo- and hydro-priming of seed considerably increased germination and early seedling properties of caraway, according to (Iman et al. 2020). Although various investigations have been carried out to examine the effects of pretreatment on the germination performance of commercially cultivated rice seeds, less attention has been paid to the use of seed osmo-priming in rice agriculture. The purpose of this study was to determine how osmo-priming time affected seed germination metrics and early seedling traits in rice.

## Materials and Methods

### Experimental Site and Materials Used

The experiment was conducted in the Plant Breeding and Seed Science Laboratory, of Joseph Sarwuan Tarka University, Makurdi in the year 2021. Two untreated rice varieties (FARO 44 and FARO 59) obtained from Kemol Agro Nig LTD was used for the study. Also sharp sand, plastic containers and measuring instrument were used for the experiment.

### Treatment and Experimental Design

The experiment was a 2 x 3 factorial combination laid out in a Completely Randomized Design (CRD) with four replications. The various treatments assigned were 2 rice varieties (FARO 44 Lowland and FARO59 Upland), 3 priming chemicals (Calcium chloride CaCl, Potassium nitrate KNO<sub>3</sub> and Polyethylene glycol PEG6000) and 4 priming durations (Control, 12, 24 and 36 hours in chemical solutions).

### Seed Priming

500g of untreated rice seeds were soaked in 1 liter of osmo-priming solutions for a period as prescribed by the treatments and re-dried under room temperature for a period of 24 hours before use in the germination test.

### Germination Test

Germination test was set up on 400 seeds per treatment according to ISTA (2015). Seeds were tested using sand method in plastic containers. The sand was washed and heat sterilized to kill soil microbes and foreign seeds before use. One hundred (100) seeds were broadcasted in each container to represent a replicate. Broadcasted seeds were constantly moistened with clean and uniform quantity of water at 8 am and 5 pm daily until 14 days that the experiment was

terminated. Germinated seeds were counted daily until the number of days for a treatment to attain a recommendable germination percentage was attained.

### Data Collection

Data was recorded on the following parameters;

Final Germination Percentage (FGP):  $FGP = \frac{N_g}{N_t} \times 100$  where  $N_g$  = Total number of seeds germinated and  $N_t$  = Total number of seeds evaluated according to Scott et al. (1984)

Mean Germination Time (MGT):  $MGT = \frac{\sum N_i T_i}{\sum N_i} = 100 / CVG$  where  $N_i$  = Number of seeds germinated per day and  $T_i$  = Number of days from the starting the experiment as described by Orchard (1977)

Coefficient of Velocity of Germination (CVG):  $100 \times \frac{\sum N_i}{\sum N_i T_i}$  where  $N_i$  = Number of germinated seeds per day and  $T_i$  = Number of days from the start of the experiment Jones and Sanders (1987)

Germination Rate Index (GRI):  $G_1 / 1 + G_2 / 2 + \dots + G_x / X$  where  $G_1$  = Germination percentage at first day and  $G_2$  = Germination percentage at the second day and so on Esehie (1994) after modification.

Seedling Height (SH): The seedlings or shoot height was determined in the standard germination test after the final count. Ten (10) normal seedlings were randomly selected from each replicate on the 8th day of broadcasting. The shoot height was measured from the point of attachment to the embryo (endosperm), to the tip of the seedling and the average shoot height was computed. The average shoot length was computed according to ISTA (2015).

Root Length (RL): Ten (10) normal seedlings were randomly selected from each replicate on the 8th day of broadcasting. The root length was measured from the point of attachment to the embryo (endosperm), down to the tip of the growing root and the average root length was computed the average shoot length was computed according to ISTA (2015).

Seedling Fresh Weight (SFW): Ten (10) normal seedlings were randomly selected from each replicate on the 8th day of broadcasting. The seedling fresh weight was measured by weighing the sampled seedlings in grams and finding the average. The average shoot length was computed according to ISTA (2015).

Seedling Dry Weight (SDW): Ten (10) normal seedlings were randomly selected from each replicate on the 8th day of broadcasting and oven dried to a constant weight. The seedling dry weight was measured by weighing the sampled seedlings in grams and finding the average. The average shoot length was computed according to ISTA (2015).

### Data Analysis

The data collected from germination test was subjected to analysis of variance (ANOVA). Treatment means were separated and ranked at 0.05% level of probability using Tukey Pairwise Comparisons (TPC). All data analysis was carried out using Minitab, version 2017.

## Results and discussions

### Variety x Chemical x Priming Duration Interaction for FGP

The interaction effects of variety, chemical and priming duration in rice showed that, at control, FARO 59 had the highest FGP (26.31) while the least (22.89) was recorded in FARO 44, this difference however is not significant. FARO 44 when soaked in  $KNO_3$  for 12 hrs; though not significant, gave the highest FGP (92.00) while FARO 44 and 59 soaked in PEG6000 had the least FGP (49.11). At 24 hrs priming duration, FARO 59 soaked in PEG6000 showed the highest FGP (96.66) and is significant different to the least FGP (79.33) recorded from FARO 59 soaked in  $KNO_3$ . Duration of soaking for 36 hrs showed no difference in FGP. The results of the present study clearly showed that more germination advantages of rice seed could be

achieved by priming with different chemicals. Rice seeds soaked for a duration of less than 24 hours gave the least final germination percentage below 50% as compared to the seeds soaked for a duration of 24 and 36 hours that gave above 75% germination percentage. The higher FGP observed in primed seeds over the non-primed seeds could be due to the several changes in the enzymes activities associated with the germination process as a result of seed priming. These activities include increase in the acid phosphatase and esterase as reported in lettuce according to (Khan et al. 1978), increase in  $\alpha$ -amylase as reported by (Farooq et al. 2006). In the case of rice and increase in antioxidant enzymes as reported in the case of wheat (Afzal et al. 2006). According to Sivritepe et al. (2003), priming with  $\text{KNO}_3$  increased also germination percentage and seedling growth under salt stressed conditions. These positive effects could probably due to the stimulatory effects of priming at the early stages of the germination process by mediation of cell division in germinating seeds.

### Variety x Chemical x Priming Duration Interaction for GRI (%)

It is found that priming treatments had significant effect on mean germination index of rice varieties for different chemical treatments (Table 1). FARO 59 and FARO 44 in the control showed no significant difference. A similar trend was observed when the seeds were primed for 12 hrs respectively across all the chemical. At 24 hrs however, FARO 59 soaked in PEG6000 gave the highest GRI (92.77) and is significantly different from the lowest GRI (51.18) recorded when the same variety was soaked in  $\text{KNO}_3$  for the same duration of 24 hrs. At 36 hrs soaking duration, FARO 59 showed highest result for GRI (93.77) and is significantly different from all interaction except FARO 59 in  $\text{KNO}_3$  (70.55). At the same duration of 36 hrs, there was no significant difference when FARO 44 and FARO 59 was soaked in  $\text{KNO}_3$ , with means of (70.55) and (69.55), respectively. The results revealed that priming enhanced rapid germination of seed compared with non-primed seed. The significant speed of germination might have been caused due to increased amylase activity that is positively correlated with the reserve mobilization and mean germination rate in rice according to (Lee and Kim 2000).

### Variety x Chemical x Priming Duration Interaction for CVG

Generally, there was consistency in CVG result although higher CVG was observed in the primed seeds over the control (Table 1). According to the result, the only significance difference recorded was in PEG6000 and  $\text{CaCl}_2$  soaked for the duration of 36 hrs s for FARO 59 and FARO 44 and 12 hr for FARO 44, respectively.

**Table 1.** Effects of Variety x Chemical x Priming Duration Interaction

| Variety | Chemical        | Duration | FGP        | GRI       | CVG         | MGT      |
|---------|-----------------|----------|------------|-----------|-------------|----------|
| FARO 59 | Unprimed        | 0 hrs    | 26.31fghi  | 26.31fghi | 67.98abcdef | 4.16bcd  |
| FARO 44 | Unprimed        | 0 hrs    | 22.89hi    | 22.89hi   | 66.61cdef   | 4.79ab   |
| FARO 59 | PEG6000         | 12 hrs   | 49.11def   | 49.11degf | 81.00abcd   | 2.26fghi |
| FARO 44 | PEG6000         | 12 hrs   | 49.11defg  | 49.11degf | 90.89abc    | 3.01cdef |
| FARO 59 | $\text{CaCl}_2$ | 12 hrs   | 56.56cde   | 56.56cde  | 87.25ab     | 2.11fghi |
| FARO 44 | $\text{CaCl}_2$ | 12 hrs   | 46.58defgh | 46.58de   | 97.36a      | 2.66fgh  |
| FARO 59 | $\text{KNO}_3$  | 12 hrs   | 54.86cde   | 54.86cde  | 87.14abcd   | 2.19fghi |
| FARO 44 | $\text{KNO}_3$  | 12 hrs   | 52.00cde   | 47.00def  | 84.66abcdef | 2.43fgh  |
| FARO 59 | PEG6000         | 24 hrs   | 96.66ab    | 92.77a    | 93.85ab     | 1.12i    |
| FARO 44 | PEG6000         | 24 hrs   | 95.33abc   | 83.15ab   | 90.94abc    | 1.47ghi  |
| FARO 59 | $\text{CaCl}_2$ | 24 hrs   | 92.00abcde | 79.22abc  | 84.64abc    | 1.48ghi  |
| FARO 44 | $\text{CaCl}_2$ | 24 hrs   | 94.00abcd  | 57.71cde  | 88.44abc    | 2.17fghi |

|                          |                  |        |            |            |           |          |
|--------------------------|------------------|--------|------------|------------|-----------|----------|
| FARO 59                  | KNO <sub>3</sub> | 24 hrs | 79.33de    | 51.18def   | 64.01def  | 3.10cdef |
| FARO 44                  | KNO <sub>3</sub> | 24 hrs | 92.66abcde | 55.17cd    | 85.93abc  | 2.43fgh  |
| FARO 59                  | PEG6000          | 36 hrs | 100.00a    | 93.77a     | 100.00a   | 1.15hi   |
| FARO 44                  | PEG6000          | 36 hrs | 98.66ab    | 62.04bcde  | 97.36a    | 2.02fghi |
| FARO 59                  | CaCl             | 36 hrs | 92.66abcde | 66.14bcde  | 86.94abc  | 2.29fghi |
| FARO 44                  | CaCl             | 36 hrs | 98.00ab    | 69.80abcde | 96.06ab   | 1.95fghi |
| FARO 44                  | KNO <sub>3</sub> | 36 hrs | 88.00abcde | 70.55abcd  | 77.76abcd | 2.11fghi |
| FARO 59                  | KNO <sub>3</sub> | 36 hrs | 86.00abcde | 69.55abcd  | 76.56abcd | 2.10fghi |
| Standard Error           |                  |        | 0.91       | 2.64       | 1.61      | 0.14     |
| Coefficient of Variation |                  |        | 8.62       | 42.47      | 16.53     | 43.77    |
| Level of Significant     |                  |        | *          | **         | *         | **       |

\*\* = Significant at 1 % level of probability and \* = Significant at 5 % level of probability

The value recorded as 64.01 is the least CVG at 24 hrs priming duration. The CVG increase in the primed seeds over the non-primed seeds indicate higher vigour which might be related to reduction of imbibition of lag time for priming treatment (Bradford 1986). Priming also causes physiological and bio-chemical changes in seed during the seed treatments and metabolic activities increases  $\alpha$ -amylase activity therefore, indicating higher vigour as reported by (Lee and Kim 2000).

#### Variety x Chemical x Priming Duration Interaction for MGT (days)

MGT decreases with increase in priming duration of up to 24 hrs. However, beyond 24 hrs soaking duration, the MGT begins to increase but was not significantly different from that of 24 hrs. At control, FARO 44 showed significant difference and also holds the highest MGT (5.33). Priming for 12 hrs was not significantly different for all the chemicals. FARO 59 soaked in PEG6000 for 24 hrs which had the least MGT (1.12), differed significantly from FARO 59 and FARO 44 soaked in KNO<sub>3</sub> for the same priming duration, with FARO 59 having the highest MGT (3.10). Significant difference was recorded at 36 hrs priming duration between the highest MGT (2.29) for FARO 49 in CaCl and the lowest MGT (1.15) from FARO 59 in PEG6000. The results revealed that priming enhanced rapid germination thereby, reducing the mean germination time of seed compared with non-primed seed. The significant enhancement in germination could due to increased amylase activity that is positively correlated with the reserve mobilization and mean germination rate in rice as reported by (Lee and Kim 2000). Similar results were also found by Harris et al. (2002).

#### Variety x Chemical x Priming Duration Interaction for SH (cm)

The result showed an increase in seedling height with respect to increase in priming duration (Table 2). At control, varieties (FARO 59 and FARO 44) showed significant difference from each other. The highest SH (8.93) was observed in FARO 59 which is significantly different from the lowest SH (3.91) observed in FARO 44. When duration of priming was increased to 12 hrs FARO59 in KNO<sub>3</sub> gave the highest SH (10.89) and was significantly different from the lowest SH (8.06) recorded when FARO 44 is soaked in PEG6000 for the same duration of 12 hrs. FARO 59 soaked in CaCl for 24 hrs gave the highest SH (12.68) and was significant to the lowest SH (8.56) observed when FARO 44 was soaked in PEG6000 for 24 hrs. when priming duration was increased to 36 hrs, FARO 59 gave the highest values for SH (12.96) and this showed significance to the least SH value at same duration (12.96) which was of observed with FARO 44 in CaCl. The results of the present study clearly showed that osmopriming enhanced seedling height of rice varieties. This is linked to what was observed in MGT where primed

seeds germinate faster giving rise to more vigorous seedling establishment than in the non-primed rice. This result is in agreement with that of Farooq et al. (2006).

### Variety x Chemical x Priming Duration Interaction for RL (cm)

Control, 12 hrs and 24 hrs showed no significance for any interactions suggesting the same effects or no difference in effect of chemical, variety and priming duration on RL. However, the RL was increasing with the increase in priming duration. At a priming duration of 36 hrs, FARO 44 soaked in PEG6000 gave the highest RL (11.14) and was significantly different to the least RL (6.08) when FARO 59 is soaked in CaCl for the same duration. The results of the present study showed that root length of rice seedling increased by priming treatments. This result is connected to what was observed the MGT where primed seeds germinate faster giving rise to more vigorous seedling establishment than in the non-primed rice. Similar result was reported by Ruan et al. (2002).

### Variety x Chemical x Priming Duration Interaction for SFW (g)

FARO 59 in the control gave the highest SFW (0.76) and is significantly different to the lowest SFW (0.07) observed in FARO 44. At 12 hrs priming duration, no significant difference is observed among all interactions for SFW. At 24 hrs priming duration, FARO 59 in CaCl had the highest SFW (1.14) which is significant to FARO 44 in KNO<sub>3</sub> which recorded the lowest SFW (0.35). At 36 hrs of priming, FARO 59 soaked in CaCl had the highest SFW (2.50) and it is significantly different to the lowest SFW (0.50) recorded when FARO 44 is soaked in PEG6000. Seed priming duration increased seedling fresh weight probably by enhancing K<sup>+</sup> condition in both seeds and seedlings as reported by (Faurooq et al. 2007). The results clearly exhibited that seed priming had effect on seedling growth. The result of the present study is in agreement with that of Farooq et al. (2006, 2007, 2008) and Tongma et al. (2001).

**Table 2.** Effects of Variety x Chemical x Priming Duration Interaction

| Variety        | Chemical         | Duration | SH        | RL       | SFW      | SDW       |
|----------------|------------------|----------|-----------|----------|----------|-----------|
| FARO 59        | Unprimed         | 0 hrs    | 8.88defg  | 6.53bcd  | 0.64cdef | 0.54abcde |
| FARO 44        | Unprimed         | 0 hrs    | 4.46i     | 7.18bcd  | 0.40ef   | 0.033de   |
| FARO 59        | PEG6000          | 12 hrs   | 10.04bcd  | 6.42cd   | 0.66cdef | 0.56abcde |
| FARO 44        | PEG6000          | 12 hrs   | 8.06g     | 6.02cd   | 0.42ef   | 0.36de    |
| FARO 59        | CaCl             | 12 hrs   | 9.17cdef  | 7.27bcd  | 0.58cdef | 0.47bcde  |
| FARO 44        | CaCl             | 12 hrs   | 8.31efg   | 7.02bcd  | 0.73bcde | 0.63bcd   |
| FARO 59        | KNO <sub>3</sub> | 12 hrs   | 10.89abc  | 6.48cd   | 0.78bcde | 0.65bcd   |
| FARO 44        | KNO <sub>3</sub> | 12 hrs   | 8.60defg  | 8.16abcd | 0.32ef   | 0.24de    |
| FARO 59        | PEG6000          | 24 hrs   | 11.18abcd | 6.27cd   | 0.88bcde | 0.71bcd   |
| FARO 44        | PEG6000          | 24 hrs   | 8.56defg  | 8.91abc  | 0.49ef   | 0.39cde   |
| FARO 59        | CaCl             | 24 hrs   | 12.68ab   | 6.48cd   | 1.14bcd  | 0.97b     |
| FARO 44        | CaCl             | 24 hrs   | 11.02abc  | 8.25abcd | 0.39ef   | 0.26de    |
| FARO 59        | KNO <sub>3</sub> | 24 hrs   | 10.82abc  | 6.56bcd  | 0.81bcde | 0.71bcd   |
| FARO 44        | KNO <sub>3</sub> | 24 hrs   | 9.58cdefg | 8.31abcd | 0.35ef   | 0.20de    |
| FARO 59        | PEG6000          | 36 hrs   | 12.96a    | 6.84bcd  | 1.32b    | 0.95bc    |
| FARO 44        | PEG6000          | 36 hrs   | 8.41efg   | 11.14a   | 0.50ef   | 0.40cde   |
| FARO 59        | CaCl             | 36 hrs   | 11.64abc  | 6.08cd   | 1.18bc   | 1.02b     |
| FARO 44        | CaCl             | 36 hrs   | 7.67gh    | 9.94ab   | 0.52def  | 0.48bcde  |
| FARO 59        | KNO <sub>3</sub> | 36 hrs   | 10.80abcd | 7.12bcd  | 2.50a    | 1.84a     |
| FARO 44        | KNO <sub>3</sub> | 36 hrs   | 8.22fg    | 7.18bcd  | 0.65cdef | 0.48bcde  |
| Standard Error |                  |          | 0.28      | 0.19     | 0.05     | 0.04      |

|                          |       |       |       |       |
|--------------------------|-------|-------|-------|-------|
| Coefficient of Variation | 26.18 | 22.22 | 47.78 | 46.28 |
| Level of Significant     | *     | **    | **    | **    |

\*\* = Significant at 1 % level of probability and \* = Significant at 5 % level of probability

### Variety x Chemical x Priming Duration Interaction for SDW (g)

It is found that priming treatments had significant effect on seedling dry weight of rice varieties for different chemical treatments (Table 2). At control, FARO 59 gave the highest SDW (0.66) while FARO 44 had the lowest SDW (0.04) and both show significant difference. An increase in priming duration to 12 hrs showed that FARO 59 soaked in KNO<sub>3</sub> gave the highest SDW (0.65) significantly different from FARO 44 soaked in KNO<sub>3</sub> with the lowest SDW (0.24). FARO 59 soaked in CaCl for 24 hrs gave the highest value (0.97) of SDW which is significantly different from FARO 44 soaked in KNO<sub>3</sub> which has the lowest value for SDW (0.20) at the same duration. At 36 hrs of priming, FARO 59 soaked in KNO<sub>3</sub> had the highest SDW (1.84) significantly different from the lowest SDW (0.40) recorded when FARO 44 is soaked in PEG6000 for the same duration. Seed priming duration increased seedling dry weight probably by enhancing K<sup>+</sup> condition in both seeds and seedlings, leading to improve α-amylase activity and the concentration of reducing sugars with amylase activity as reported by (Faurooq et al. 2007). The results clearly showed that seed priming had effect on seedling growth. The result of the present study is in agreement with that of Farooq et al. (2006, 2007, 2008) and Tongma et al. (2001).

## Conclusions

From the results of the present study, it may be stated that osmo-priming treatments enhanced rapid seed germination while lessening the mean germination time and enhancing seedling growth by different priming duration's. The results showed that chemical priming treatments had significant effect on final germination percentage, mean germination time, germination rate index, coefficient of velocity of germination, seedling height and seedling weight of rice seeds. Primed with KNO<sub>3</sub>, PEG6000 and CaCl solution for a period of 24 - 36 hours is a remarkable technique for improving seed germination and seedling growth of rice. The no priming treatment showed the lowest final germination percentage, mean germination time, germination rate index, coefficient of velocity of germination, seedling height and seedling weight of rice seeds. Therefore, the present study concludes that improvement of germination capacity and rapidity of germination of rice seed could be possible by employing osmo-priming treatment.

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