# Interactive Effect of Potassium Nitrate and Silicon Dioxide Approach for Enhanced Germination and Seedling Growth of Rice Var. FARO44

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**Abstract**

Presoaking of cereals and legumes is an easy, simple and low-skill required approach for promoting faster germination as well as seedling growth that is practiced worldwide. In this study, laboratory experiments were performed to examine the benefits of combination of potassium nitrate and silicon dioxide treatments on germination and seedling growth of FARO44 rice. In the laboratory, FARO44 rice seeds soaked in 2.5% $KNO_3$+3% $SiO_2$ and 5% $KNO_3$+3.5% $SiO_2$ were germinated in specimen bottles for two weeks. Each treatment had five replications. The results found that soaking in 2.5% $KNO_3$+3% $SiO_2$ and 5% $KNO_3$+3.5% $SiO_2$ significantly increased germination, seedling growth and seedling vigour. However, there were no significant differences between 5% $KNO_3$+3.5% $SiO_2$ and 2.5% $KNO_3$+3% $SiO_2$ in improving germination and seedling growth of FARO44 rice. These combined concentrations of potassium nitrate and silicon dioxide are thus recommended for improving seed germination and seedling growth of FARO44 rice.

**Keywords:** *Presoaking, potassium nitrate, silicon dioxide, germination, seedling growth*

## Introduction

Rice (*Oryza sativa* L.) is one of the most essential cereal crops cultivated on the earth surface and it is the major staple being consumed by billions of people in Asia chiefly produced on irrigation fields (Esmaeili & Heidarzade, 2012; Yousof, 2013). It is a plant which belongs to the family of grasses Poaceae or Gramineae. At the present global population growth, the requirement of rice significantly increases while many countries are confronting challenges of production of more rice at a lesser cost in a deteriorating environment (Kareem & Ismail, 2013).

Globally, rice is one of the three essential food crops being eaten as a main diet by about half of the world's population. The world production of rice has been estimated at around 650 million tonnes while the land under cultivation of rice has been estimated at around 156 million hectares (Oko, Ubi, Efisue & Dambaba, 2012). Asia is the major producer of rice which accounts for about 90% of the global production. Moreover, over 75% of the world's rice supply is being consumed within the Asian countries, therefore it is of enormous importance to Asian food security (Hussain et al., 2015). Reports have shown that rice is a diet for greater than 50% of people in the world particularly East and Latin America as well as Southeast Asia. It is cultivated on a vast acreage of land covering about 11% of the global cultivable land (Hussain et al., 2015). Oryza sativa and Oryza glaberrima are the two domesticated rice species that are being cultivated while the other twenty-two species are in wild. Rice is the sole crop that led to the so-called green revolution between 1960s and 1970s.

Global production of rice has been ravaged by so many problems that consist of salinity, pest infestation, and drought, higher and low temperature extremes; these inevitably reduce germination and seedling growth that eventually lead to decline in yields as well as food security crises. There are a lot of research conducted in addressing the problems of low seed germination, poor seedling emergence on many rice varieties. However, there is a dearth of study on enhancing germination and seedling establishment of FARO44 rice using combined potassium nitrate ($KNO_3$) and silicon dioxide ($SiO_2$). Thus, this paper examined the benefits of combination of $KNO_3$ and $SiO_2$ treatments on germination and seedling growth of FARO44 rice.

## Materials and Methods

### Study Site

This study was carried out in the Biology Laboratory of the Department of Science Laboratory Technology, School of Science, Mai Idris Alooma Polytechnic, Geidam, Yobe State, Nigeria.

### Sample Collection

FARO44 rice seeds were gotten from Badeggi Rice Research Institute in Niger State, Nigeria in West Africa. FARO44 rice is a new rice variety developed in Nigeria, it is cultivated in different parts of Nigeria under both rain-fed and irrigation agriculture (Oluwaseyi & Nehemmiah, 2016).

### Optimization of Presoaking Duration and Chemical Concentrations

Preliminary studies were carried out to pre-optimize the seed presoaking treatments and duration. FARO44 rice seeds were soaked in different concentrations of potassium nitrate ($KNO_3$) as well as silicon dioxide ($SiO_2$) (Zheng et al., 2016). The effective concentrations of 2.5% and 5% $KNO_3$ and 3% and 3.5% $SiO_2$ and 8 hour soaking duration were selected on the bases of germination attributes and seedling growth performances such as germination percentage, germination index, mean germination time, seedling length, shoot & root length and seedling vigour (Hussain et al., 2016; Zheng et al., 2016).

**Seed Presoaking treatment and Germination**

Before soaking seeds, beakers, Petri dishes and specimen bottles were thoroughly washed and dried in an oven for 24 hours at 50 ºC; and the soaking solutions of $SiO_2$ and $KNO_3$ were prepared and kept in a fridge.

Sterilized FARO44 rice seeds were presoaked separately in 20 ml each of 2.5% and 5% (w/v) of $KNO_3$ and 3% and 3.5% solutions (w/v) of $SiO_2$ for 8 hours according to the methods described by Chunthaburee et al. (2014), Yan (2015) & Abdel Latef & Tran (2016). The systems were kept in the dark laboratory growth room at 25 ºC. The ratio of 1:7 (w/v) seeds mass to volume of solution was used throughout the soaking processes. After seed soaking treatments, seeds were painstakingly washed with distilled water three times and dried in shade for 48 hours to obtain their initial weight of 10.2% at room temperature (Anosheh et al., 2011; Khan et al., 2019)

Presoaked rice seeds in combined concentrations of $KNO_3$ and $SiO_2$ were germinated in specimen bottles lined with Whatman filter (No.1 90mm) and 7 ml distilled water was applied for two weeks in laboratory growth room with temperature of 25 ºC (Anwar et al., 2013; Khan et al., 2019). Each presoaking treatment had five replications. The first record of germinations was taken on the second day while the last one was taken on the fourteenth day. Seed was considered as germinated when the emerged radicle was about 2 mm in length (Chunthaburee et al., 2014; Ruttanaruangboworn et al., 2017). All the measurements were based randomly picked six normal rice seedlings from every replication. Final germination percentages were computed at the end of the experiments (Yan, 2015).

**Experimental design and data analyses**

The seed presoaking experiments were placed in a completely randomized design and each treatment had five replications (Azeem et al., 2015). Shapiro Wilk test was used for assessing the data normality. One-way ANOVA) was executed for comparing the effects of various presoaking treatments on germination characteristics and seedling growth parameters studied (Khatami et al., 2015). Significant means differences were separated with Duncan's Multiple Range Test (DMRT) ($P \leq 0.05$) (Heydariyan et al., 2014; Yan, 2015).

**Results**

**Combined potassium nitrate and silicon dioxide presoaking enhanced germination characteristics of FARO44 rice**

Analyses of variance on influence of combined potassium nitrate and silicon dioxide soaking on FARO44 rice germination showed that were no significant effect ($P < 0.05$) on the percentage of germination between the soaked seeds and controls as seen in Table 1 below.

Similarly, the analyses of variance showed that there were significant effects of $KNO_3$ and $SiO_2$ soaking on germination index of FARO44 rice ($P < 0.05$) between primed seeds and the controls as shown Table 1 below. Both 5% $KNO_3$+3.5% $SiO_2$ and 2.5% $KNO_3$+3% $SiO_2$ soaked have high germination indices of 3.5 and 3.4 compared to unsoaked rice seeds of 2.5 respectively. Daily germination of seeds is referred to as germination index (Fetouh & Hassan, 2014).

The result of the variance analysis further showed that there were significant differences ($P < 0.05$) in the time taken by seeds to complete germination between soaked rice seeds and controls. Both 5% $KNO_3$+3.5% soaked seeds and 2.5% $KNO_3$+3% $SiO_2$ rice seeds took about two days and few hours for completion of germination compared to three days and four hours of control as presented in Table 1.

**Table 1. $KNO_3$+$SiO_2$ soaking influence on germination attributes of FARO44 Rice**

| Concentration of soaking agents | Germination percentage (%) | Germination index | Mean germination time (days) |
|---|---|---|---|
| Control | 100 ± 0.0 | 2.5 ± 0.4$^{b}$ | 3.4 ± 0.0$^{a}$ |
| 5% $KNO_3$+3.5% $SiO_2$ | 100 ± 0.0 | 3.5 ± 0.1$^{a}$ | 2.5 ± 0.1$^{b}$ |
| 2.5% $KNO_3$+3% $SiO_2$ | 100 ± 0.0 | 3.4 ± 0.1$^{a}$ | 2.6 ± 0.1$^{b}$ |
| **Levels of Significance** | ns | 0.000 | 0.000 |

Means±SE values in the columns having the same letter (s) are not significantly different according to Duncan Test ($P < 0.05$), while figures with different letters were statistically different

**Combined potassium nitrate and silicon dioxide presoaking improved growth of FARO44 rice seedling**

Analyses of variance of combined potassium nitrate and silicon dioxide presoaking on rice seeds showed that were significant effect ($P < 0.05$) on seedling growth as presented in Table 2 below. Rice seeds soaked in 5% $KNO_3$+3.5% $SiO_2$ and 2.5% $KNO_3$+3% $SiO_2$ had longer seedlings. Seedlings of 2.5% $KNO_3$+3% $SiO_2$ soaked seeds were slightly longer than seedlings from 5% $KNO_3$+3.5% $SiO_2$ soaked seeds.

Likewise, the ANOVA results showed that plumule length of FARO44 rice seedlings were considerably affected by 5% $KNO_3$+3.5% $SiO_2$ soaking treatments ($P < 0.05$) as shown in Table 2. However, 2.5% KNO3+3% $SiO_2$ soaking had no effect on increasing plumule length of FARO44 rice seedlings in comparison to unsoaked control. Similarly, both 5% $KNO_3$+3.5% $SiO_2$ and 2.5% $KNO_3$+3% $SiO_2$ soaked rice seedlings has considerably longer roots compared to roots of control (unsoaked) seedlings. However, seedlings of 2.5% KNO3+3% $SiO_2$ soaked seedlings had the longest roots of 9.8 cm as shown in Table 2 below.

**Table 2. Effect of 5% $KNO_3$+3.5% $SiO_2$ and 2.5% $KNO_3$+3% $SiO_2$ presoaking on seedling growth FARO44 rice**

| Concentrations of soaking agents | Seedling height (cm) | Plumule length (cm) | Root length (cm) |
|---|---|---|---|
| Control (unsoaked) | 11.3 ± 0.3$^{b}$ | 6.2 ± 0.2$^{ab}$ | 5.6 ± 0.3$^{c}$ |
| 5% $KNO_3$+3.5% $SiO_2$ | 14.7 ± 0.3$^{a}$ | 6.5 ± 0.2$^{a}$ | 8.4 ± 0.3$^{b}$ |
| 2.5% $KNO_3$+3% $SiO_2$ | 15.4 ± 0.4$^{a}$ | 5.9 ± 0.1$^{b}$ | 9.8 ± 0.3$^{a}$ |
| **Levels of** | 0.000 | 0.025 | 0.000 |

| Significance |
|---|

Means±SE values in the columns having the same letter (s) are not significantly different according to Duncan Test (P<0.05), while figures with different letters are statistically different.

**Combined potassium nitrate and silicon dioxide presoaking increased seedling biomass of FARO44 rice.**

Variance analyses of combined potassium nitrate and silicon dioxide treatments had significant effect (P < .05) fresh and dry seedling biomass of FARO44 rice as detailed in Table 3. Rice seeds soaked in 2.5% $KNO_3$+3% $SiO_2$ appeared to have higher fresh seedling biomass of 135.5 mg while 5% $KNO_3$+3.5% $SiO_2$ soaked rice seedlings had 123.5 mg seedling fresh biomass compared to control (unsoaked) with the lowest seedling fresh biomass. However, 5% $KNO_3$+3.5% $SiO_2$ soaked seedlings had the highest seedling dry biomass of 29.6 mg while 2.5% $KNO_3$+3% $SiO_2$ soaked seedling with 28.8 mg compared to control with 28.2 mg.

**Table 3. Effect of 2.5% $KNO_3$+3% $SiO_2$ and 5% $KNO_3$+3.5% $SiO_2$ soaking on fresh and dry biomass of FARO44 rice seedlings**

| Concentrations of soaking agents | Fresh seedling biomass (mg) | Dry seedling biomass (mg) |
|---|---|---|
| Control (unsoaked) | $97.4 \pm 0.9^c$ | $28.2 \pm 0.1^c$ |
| 5% $KNO_3$+3.5% $SiO_2$ | $123.5 \pm 1.9^b$ | $29.6 \pm 0.2^a$ |
| 2.5% $KNO_3$+3% $SiO_2$ | $135.5 \pm 2.2^a$ | $28.8 \pm 0.2^b$ |
| **Levels of Significance** | 0.000 | 0.000 |

Means±SE values in the columns having the same letter (s) are not significantly different according to Duncan Test (P < 0.05), while figures with different letters were statistically different.

**Combined potassium nitrate and silicon dioxide presoaking improved seedling vigour of FARO44 rice seedlings**

The variance analyses on combined potassium nitrate and silicon dioxide treatments on FARO44 rice seeds showed that there was significant effect (P < 0.05) of seed soaking on both seedling vigour index I and II as shown in Table 4. Rice seeds soaked in 2.5% $KNO_3$+3% $SiO_2$ appeared to have higher seedling vigour index I of 1540.3 while 5% $KNO_3$+3.5% $SiO_2$ soaked seedlings have seedling vigour index I of 1468.7 compared to control seedling having the lowest seedling vigour index I of 1127.3. On the other hand, 5% $KNO_3$+3.5% $SiO_2$ soaked seedlings had the highest seedling vigour index II of 2962 while 2.5% $KNO_3$+3% $SiO_2$ soaked seedlings have the seed vigour index II of 2880 compared to control with the lowest SVI II of 2820 respectively as seen in Table 4.

**Table 4. Effect of 2.5% $KNO_3$+3% $SiO_2$ and 5% $KNO_3$+3.5% $SiO_2$ soaking on seedling vigour of FARO44 rice seedling**

| Concentrations of soaking agents | Seedling Vigour Index I (GP × seedling Length) | Seedling Vigour Index II (GP × seedling dry weight) |
|---|---|---|
| Control | 1127.3±30$^{b}$ | 2820±11.8$^{c}$ |
| 5% $KNO_3$+3.5% $SiO_2$ | 1468.7±25.8$^{a}$ | 2962±17.2$^{a}$ |
| 2.5% $KNO_3$+3% $SiO_2$ | 1540.3±35.8$^{a}$ | 2880±17.2$^{b}$ |
| **Levels of Significance** | 0.000 | 0.000 |

Means±SE values in the columns having the same letter (s) are not significantly different according to Duncan Test ($P < 0.05$), while figures with different letters were statistically different.

## Discussions

This study indicated that presoaking FARO44 rice seeds in 5% $KNO_3$+3.5% $SiO_2$ and 2.5% $KNO_3$+3% $SiO_2$ increased germination characteristics and growth of FARO44 rice seedling. However, there were no significant differences between 5% $KNO_3$+3.5% $SiO_2$ and 2.5% $KNO_3$+3% $SiO_2$ in improving germination and seedling growth of FARO44 rice. Enhancement of germination and seedling growth of rice might be associated with the roles of $KNO_3$ and $SiO_2$ in activating several growth promoting enzymes, repair of nucleic acid components and increased water imbibition and accumulation of soluble osmolytes in primed seedlings. Better seedling growth performance in $KNO_3$ and $SiO_2$ presoaked rice seedlings might be as a result of accelerated cell division as well as elongation. It is clear that radical scavenging enzymes like peroxidase, CAT and SOD which play vital roles in fast growth in plants are increased by seed presoaking (Varier et al., 2010). Field crop field growth had been reported to have improved due to seed soaking (Giri and Schillinger, 2003). Agreeing the results of this study of improvement of rice seedling growth performance by $KNO_3$, $SiO_2$ and SA presoaking, Ramzan et al. (2010) reported that $KNO_3$ presoaking enhanced germination, seedling length, bulb diameter and weight as well as decreased mean germination time and time to reach 50% germination of gladiolus (*Gladiolus alatus*). In line with results of this study of enhancement of seedling length, shoot length and root length by $KNO_3$, $SiO_2$ and SA presoaking, Ahmad et al. (2012) found that maize presoaking in SA and ascorbic acid improved shoot length and root length. Stem length, leaf area and leaf number of maize were increased by SA presoaking under salt stress (Abbastash et al., 2013). Contrary to these results, Jamal et al. (2011) argued that 6 wheat varieties soaked NaCl under salinity stress showed no significant increase of plant height and root length. However, leaf number and tiller number of wheat varieties were increased by NaCl presoaking. Improve seedling growth and vigour of plants is for the fact that seed presoaking stimulates the production and activation of many enzymes that speed up breaking down as well as stored reserve mobilization. However, most nutrient utilization and breakdown occur after radicle appearance (Varier et al., 2010). In agreement with results of this study, Salah et al. (2015) found that in in two rice cultivars presoaked in 30% PEG under nano-zinc oxide stress, shoot length, root length and surface area of leaf were markedly increased compared to unprimed controls. Consistent with results of this study, previous study revealed that three rice cultivars presoaked in beta-amino butyric acid exposed to salinity and drought stresses exhibited improved shoot length, fresh and dry biomass (Jisha & Puthur, 2016). Agreeing these results, Farooq et al. (2013) reported that two wheat species presoaked in ascorbic acid and water exposed to drought stress showed improved shoot and root lengths, leaf number, leaf elongation & emergence, and leaf size as a result of enhanced antioxidants, tissue water status, phenolics and proline content. Similarly, results of Hameed et al. (2015) showed that nitroprusside presoaking of wheat increased shoot and root lengths due to improved activities of CAT, SOD, protease and low lipid peroxidation. However, hydropriming showed no effects on improving these attributes. According to Galahitigama & Wathugala, (2016) rice primed with $KNO_3$, KCl, $ZnSO_4$, $CaCl_2$ and ascorbic acid under salt stress exhibited enhanced seedling length and leaf number. Supporting this study, previous results of Moulick et al. (2016) found that selenium osmoprimed rice under arsenic constraint showed improved shoot and root length associated with improved proline and phenolic content as well as low lipid peroxidation. As indicated in this study of improving FARO44 rice growth by seed priming, findings of $KNO_3$, mannitol and wood vinegar primed rice seedlings under salinity stress revealed that shoot and root lengths were substantially increased due to improved membrane stability and proline accumulation in primed seedlings (Theerakulpisut et al., 2016). Rehman et al. (2015) reported that maize primed with Moringa leaf extract, SA and $CaCl_2$ showed increased plant height, leaf area index, and leaf water status as well as decreased membrane stability.

## Conclusion

Presoaking of FARO44 rice seeds in combined 2.5% $KNO_3$+3% $SiO_2$ and 5% $KNO_3$+3.5% $SiO_2$ increased germination, seedling growth and vigour. However, there were no significant differences between 5% $KNO_3$+3.5% $SiO_2$ and 2.5% $KNO_3$+3% $SiO_2$ in improving germination and seedling growth of FARO44 rice. These combined concentrations of potassium nitrate and silicon dioxide are thus recommended for improving seed germination and seedling growth of FARO44 rice.

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