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Seed Chemical Priming for Germination and Seedling Vigour Traits in Gmelina (*Gmelina arborea*) Seeds from Different Fruit Maturity Levels

[1]Adebisi Moruf, [1]Kehinde Tolulope, [2]F. Adekunle Michael and [1]Adenaike Adewunmi
[1]Department of Plant Breeding and Seed Technology, [2]Department of Forestry and Wildlife Management, Federal University of Agriculture, PMB 2240, Abeokuta, Ogun State, Nigeria

Corresponding Author: Adebisi Moruf, Department of Plant Breeding and Seed Technology

ABSTRACT

Seed priming has been reported to improve germination and emergence in seeds of many crops. A study was conducted to determine the effect of seven chemical priming media on germination and seedling vigour traits of seeds from different fruit maturity levels, (using fruit colour as an index of maturity thus: yellow, green and brown) of Gmelina (*Gmelina arborea*). All priming media were dissolved in 100 mL of distilled water and all treatments were synchronized. Data obtained on seed germination, mean germination time, seedling height and seedling vigour were statistically analyzed. Seeds from fruits of different maturity levels and different priming treatments showed considerable differences in all the seed quality parameters examined. Seeds from yellow fruits had the best germination, seedling vigour index, seedling height and mean germination time when treated with 20%PEG (polyethylene glycol). Chemical priming of seeds with 4% KCl gave poor seed quality in all the fruits colours. Hence seeds from yellow fruits treated with 20% PEG could be used in producing high quality seedlings in forest plantation establishment.

Key words: Fruit maturity colour, priming media, seed improvement, seed quality, seed treatment

INTRODUCTION

Gmelina arborea have been found to be a deciduous tree of 120-300 cm high and 60-100 cm in diameter. Also, it is native to tropical moist forest from India, Burma, and Sri Lanka to southern China, Gmelina is widely introduced, in Brazil, Gambia, Honduras, Ivory Coast, Malaysia, Malawi, Nigeria, Panama, Philippines, and Sierra Leone. In Nigeria, Gmelina was reported to be originally used for supply of pulpwood for pulp and paper mills but the closure of these industries, the species is now used as materials in the building construction (Akachukwu, 1993).

Gmelina plantations have been reported to provide raw logs for conversions into sawn timber of uniform grades and sizes (Adetogun and Omole, 2007).

Gmelina has been described as an interesting species due to the unique characteristics it possess such as ease and low cost of establishment, rapid early growth, early returns and good wood characteristics like high durability, good yield and quality of pulp (Salim *et al*., 2002). Gmelina is moderate in durability with service life of less than 15 years. Pests and diseases have been reported to have prevented the planting of gmelina on a large scale within its natural distribution area. In addition, poor stem and branching characteristics and difficulty existing in establishing the wood

in pulp mills have been found to be some of the problems with Gmelina in Nigeria. Low seed germination has been reported in Gmelina (Omoyiola, 1974; Okoro, 1983; Adebisi *et al.*, 2011a) while Hartman and Koster (1975) have reported the presence of inhibitory substances in the fleshy pericarp of fruits of Gmelina.

Adebisi *et al.* (2011a) also discovered that the low seed germination rate in Gmelina may be due to over ripeness or over fermentation of the pulpy part of the fruit which causes death of the embryo, thereby creating problem of seedling establishment.

Germination of seeds of gmelina has been found to be affected by several factors such as; fruit colour, size, fermentation, depulping, and time of fruit collection. Adebisi *et al.* (2011a) have reported that seeds from yellow brown fruits had the best germination performance traits especially when soaked in water for 48 h. In spite of huge resources being spent of seedling establishment and increasing demand for the tree, there is still problem of low germination rates. Hence, there is a need for a simple technology that will help to improve the germination rate and enhance uniform seedling emergence in gmelina seeds. Seed priming has been identified as one of such techniques.

Priming has been described as a beneficial method which helps in improving seed performance and field establishment of some crops (Kattimani *et al.*, 1999).

Improved germination and emergence in seeds of many crops and tree species, particularly seeds of vegetables and small seeded grasses has been successfully attributed to seed priming (Dell'Aquila and Tritto, 1991; Donaldson *et al.*, 2001, Adebisi *et al.*, 2011b). This technique is also used for improvement of germination speed, germination vigour, seedling establishment and yield (Talebian *et al.*, 2008; Bodsworth and Bewley, 1981).

Although, seed priming techniques have been found effective for better germination and seedling establishment in *Cordia* (Adebisi *et al.*, 2011b) under controlled conditions. No comprehensive information has yet been recorded and done to evaluate the response to a wide range of seed invigoration techniques to enhance emergence, seedling vigour traits and growth of *Gmelina arborea* seeds from different fruit maturity levels. Hence the study was initiated to determine the effect of seed priming media and duration of treatment on germination, vigour and growth traits of Gmelina seeds from different fruit maturity colour and to find out the most promising seed priming treatment for improved seed quality in gmelina.

MATERIALS AND METHODS

Seed material: Fruits of gmelina were collected from Olokemeji Forest Reserve, Olokemeji village, Ogun State, Nigeria. Based on the physical appearance of the matured fruits of gmelina and using colour as an index of level of maturation and ripeness, three categories of fruits of the species green fruits, yellow fruits and brown fruits were collected from fruiting trees.

Seed preparation: Gmelina fruits were depulped. The fleshy cover was rubbed off using stones by hand, and then rubbed with sand and water to remove the remaining dry pulp from the stones. The stones were then dried under ambient laboratory conditions in the laboratory for four weeks.

Seed priming media: Seven priming media were investigated in the study, these media were: Water (Distilled water as control), 2% Potassium chloride (KCl) (w/v), 4% KCl (w/v), 0.5% Potassium hydrophosphate (KH_2PO_4) (w/v), 1% KH_2PO_4 (w/v), 10% Polyethylene glycol (PEG) 8000(w/v), 20% PEG 8000 (w/v). All priming media were dissolved in 100 mL of distilled water and all treatments were synchronized.

Seed conditioning after priming: All seeds were removed from priming media at the same time after 12 h of soaking and then rinsed thoroughly with distilled water and hand dried lightly using blotting paper. While still damp, seeds including control were treated with apron plus (fungicide) and then allowed to dry on paper towel at room temperature (28-29°C).

Experimental design: The study was a factorial in completely randomized design with three replications. There were 42 experimental units consisting of three factors, priming media (7), fruit maturity level (3), which were replicated three times.

Seed quality evaluation: Seed samples were taken from each treatment lot and tested for the following seed quality.

Standard seed germination: A total of 100 seeds were counted randomly from each hand graded seed lots in three replications for the trial. Seeds from each treatment unit were sown 5 cm deep in plastics pots (dimensions 30×30 cm) filled with sterilized soil with 1 cm spacing between seeds. The pots were arranged randomized design in the laboratory and germination count of normal (healthy or strong) seedlings was taken at 14 up to 30 days. Observation were made on germination every three days and percentage of standard germination was determined (ISTA, 1995).

Mean germination time (MGT): This was recorded according to Alvarado *et al.* (1987) using the following formula:

$$MGT = \frac{\sum T_i N_i}{\sum N_i}$$

where, N_i is the number of newly germinated seeds at time T_i.

Seedling height: This was determined using a ruler in centimeter (cm) to calculate the heights of ten randomly selected seedlings.

Seedling vigour index (SVI): SVI level of each fruit colour was calculated according to Kim *et al.* (1994) as:

$$SVI = \frac{\text{Germination (\%)} \times \text{Seedling height (cm)}}{100}$$

Statistical analysis of data: Data obtained from the work were subjected to analysis of variance (ANOVA) with the significance level tested at 1 and 5% probability levels. Significance of treatment means were separated using Tukey HSD test at 5% probability level.

RESULTS

Table 1 shows a summary of ANOVA for seed quality traits evaluated after priming of seed with three different maturity levels in *Gmelina arborea*. Fruit colour, priming treatment and the interaction effects were highly significant ($p = 0.01$) on seed germination of *Gmelina arborea*. Fruit

Table 1: Summary of ANOVA for seed quality traits evaluated after chemical priming of seed with three different maturity levels in *Gmelina arborea*

Source	df	Seedling emergence (%)	Seedling height (cm)	Mean emergence time (days)	Seedling vigour index
Rep	2	19.44^{ns}	33.93**	4.86^{ns}	0.08^{ns}
Fruit colour (C)	2	102026.02**	7621.39**	25506.50**	4570.21**
Priming treatment (T)	6	970.45**	10.54^{ns}	242.61**	44.33**
C×T	12	661.57**	6.82^{ns}	165.39**	30.23**
Error	166	267.97	13.32	66.99	12.48

**Significant at 1% level of probability, ns: Not significant

Table 2: Effect of chemical priming treatments on seedling emergence traits over fruit maturity colour treatments of *Gmelina arborea*

Treatment	Seed germination (%)	Seedling height (cm)	Mean germination time (days)	Seedling vigour index
Distilled water	46.48^{a}	14.58^{a}	23.24^{ab}	9.69^{ab}
2% KCl	44.85^{b}	13.79^{a}	22.43^{ab}	9.27^{ab}
4% KCl	36.74^{c}	14.66^{a}	18.37^{b}	7.80^{b}
0.5% KH_2PO_4	51.15^{a}	13.94^{a}	25.57^{a}	10.80^{a}
1% KH_2PO_4	52.60^{a}	14.83^{a}	26.30^{a}	11.04^{a}
10% PEG	44.41^{b}	14.89^{a}	22.20^{ab}	9.41^{ab}
20% PEG	54.11^{a}	15.65^{a}	27.06^{a}	11.53^{a}

Mean followed by the same alphabet along the column are not significantly different from one another at 5% probability level, KCl: Potassium chloride, KH_2PO_4: Potassium hydrophosphate, PEG: Polyethylene glycol

colour and priming treatment effects were highly significant (p = 0.01) on seedling height, mean germination time and seedling vigour index whereas only fruit colour effect recorded significant effect on seedling height.

Effect of chemical priming treatments on seed quality traits of *Gmelina arborea* as shown in Table 2 revealed that seeds treated with 20% PEG, 1% KH_2PO_4, and 0.5% KH_2PO_4 had the similar higher seed germination values of 54.11, 52.60 and 51.15, respectively while seeds treated with 4% KCl had the lowest germination percentage of 36.74%. Seeds treated with distilled water, 2% KCl and 10% PEG had intermediate germination percentages of 46.48, 44.85 and 44.41, respectively. All treatments had statistically similar effects for the seedling height. Seeds primed with 20% PEG, 1% KH_2PO_4, and 0.5% KH_2PO_4 had similar higher mean germination time of 27.06, 26.30 and 25.57 days, respectively and seedling vigour index of 11.53, 11.04, and 10.80 respectively. Though not significantly different from values obtained from seeds primed with distilled water, 2% KCl and 10% PEG.

Figure 1 displays the effect of fruit maturity colour on seed quality traits of *G. arborea* over priming treatments. The result revealed that seeds from yellow fruit colour gave the highest germination which was significantly different from green colour while brown coloured fruits gave the lowest germination (0.76%). Also, seeds from yellow fruit colour gave the highest seedling height, mean germination time and seedling vigour index followed by the seeds obtained from green colour fruits while the brown fruited seeds recorded the lowest values in all the four seed quality traits examined.

Table 3 shows the effect of priming treatment and fruit maturity colour on the seed germination and mean germination time. Differential responses occurred among the treatments under each of the fruit maturity levels/colour for germination and mean germination time. On response of seed germination to priming treatments, seeds from yellow fruits treated with 20% PEG solution had the

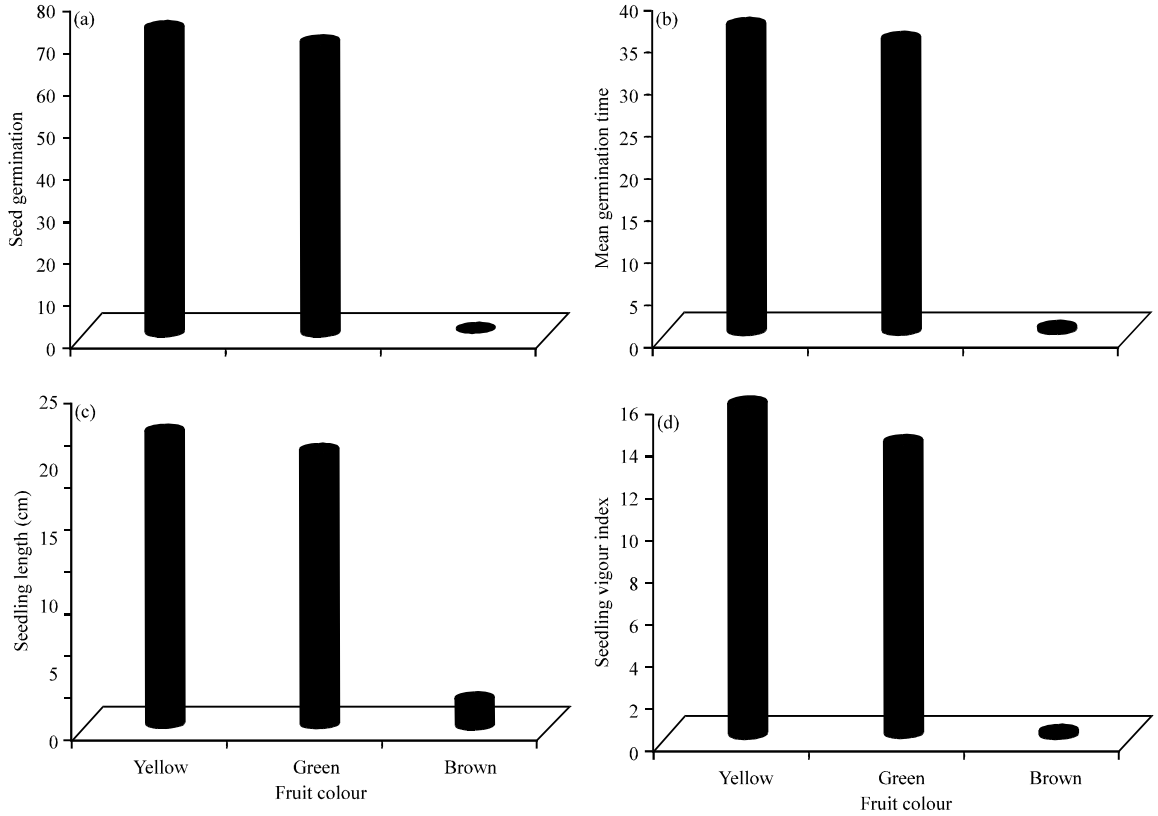

Fig. 1(a-d): Effect of fruit maturity colour on seed quality traits of *Gmelina arborea* over priming treatments (a) Seed germination, (b) Mean germination time, (c) Seedling height and (d) Seedling vigour index

Table 3: Effect of chemical priming treatment and fruit maturity colour on the seed germination and mean germination time of *Gmelina arborea*

	Seed germination (%)			Mean germination time (days)		
Treatments	Yellow	Green	Brown	Yellow	Green	Brown
Distilled water	77.78^{b}	60.78^{f}	0.89^{b}	38.89^{b}	30.39^{f}	0.44^{a}
2% KCl	75.56^{c}	59.00^{g}	0.05^{c}	37.78^{b}	25.50^{g}	0.02^{a}
4% KCl	46.67^{e}	62.67^{e}	0.89^{b}	23.33^{d}	31.33^{e}	0.44^{a}
0.5% KH_2PO_4	77.78^{b}	75.67^{b}	0.02^{c}	38.89^{b}	37.83^{b}	0.10^{a}
1% KH_2PO_4	75.56^{c}	81.33^{a}	0.89^{b}	37.78^{b}	40.67^{a}	0.44^{a}
10% PEG	62.22^{d}	70.11^{d}	0.89^{b}	31.11^{c}	35.06^{d}	0.44^{a}
20% PEG	88.89^{a}	71.67^{c}	1.78^{a}	44.44^{a}	35.83^{c}	0.89^{a}

Means followed by the same alphabet along the column are not significantly different from one another at 5% probability level, KCl: Potassium chloride, KH_2PO_4: Potassium hydrophosphate, PEG: Polyethylene glycol

highest germination (88.89%), followed by 0.5% KH_2PO_4 treatment (77.78%) and distilled water (77.78%) whereas other treatments had similar statistical values and 4% KCl treatment gave the lowest germination of 46.67%. also germination of seeds from green fruits treated with 1% KH_2PO_4 was highest (81.33%), followed by 0.5% KH_2PO_4 (75.67%) treatment and 20% PEG with germination value of 71.67% while germination of seeds from green fruits with 2% KCl treatment

Table 4: Effect of chemical priming treatment and fruit maturity colour on seedling height and seedling vigour index of *Gmelina arborea*

	Seedling height (cm)			Seedling vigour index		
Treatments	Yellow	Green	Brown	Yellow	Green	Brown
Distilled water	21.60^{b}	19.97^{a}	2.17^{b}	16.78^{b}	12.12^{e}	0.17^{a}
2% KCl	21.26^{b}	20.10^{a}	0.04^{c}	15.99^{d}	11.82^{e}	0.0027^{b}
4% KCl	21.36^{b}	20.40^{a}	2.23^{b}	10.43^{f}	12.79^{d}	0.18^{a}
0.5% KH_2PO_4	21.62^{b}	20.21^{a}	0.09^{c}	16.99^{b}	15.42^{b}	0.13^{b}
1%KH_2PO_4	21.53^{b}	20.41^{a}	2.46^{b}	16.27^{c}	16.65^{a}	0.20^{a}
10% PEG	22.32^{a}	20.14^{a}	2.23^{b}	13.94^{e}	14.11^{c}	0.18^{a}
20% PEG	22.21^{a}	20.18^{a}	4.57^{a}	19.78^{a}	14.44^{c}	0.37^{a}

Means followed by the same alphabet along the column are not significantly different from one another at 5% probability level, KCl: Potassium chloride, KH_2PO_4: Potassium hydrophosphate, PEG: Polyethylene glycol

had the lowest (59.0%). The response of seed germination from brown fruit to priming chemicals was not encouraging. Although treatment with 20% PEG showed germination of 1.78% which was the highest for brown fruited seeds, other treatment solutions had germination of below 1%. For mean germination time response to chemical priming treatments, seeds from yellow fruits treated with 20% PEG had highest value of 44.44 days. Treatment with 4% KCl had the lowest value of 23.33 days. However, the lower the mean germination time the better. Mean germination time of seeds from green colour treated with 1% KH_2PO_4 had the highest mean germination time value (40.67 days), closely followed by 0.5% KH_2PO_4 treatment with 37.83 days while the lowest mean germination time of 25.50 days was recorded for treatment with 2% KCl.

In Table 4, the effect of chemical priming treatment and fruit maturity colour on the seed seedling height and seedling vigour index revealed that significant differences existed among the treatments for seedling height and seedling vigour index under each of the fruit maturity colours. For seedling height, seeds from yellow fruits treated with 10 and 20% PEG had the highest seedling height (22.21-22.32 cm) whereas other treatments had statistically similar seedling heights which ranged between 21.26 and 21.62 cm. Seeds from green fruits treated with all the treatments had seedling heights which ranged from 19.97 cm for distilled water treatment to 1% KH_2PO_4 but the values were statistically not different among the chemical treatments. Seeds from brown fruits primed with 20% PEG gave the highest seedling height whereas other priming treatments had statistically similar values except 2% KCl and 0.5% KH_2PO_4 which recorded lower and statistically similar values. In terms of seedling vigour, seed from yellow fruits treated with 20% PEG had the highest value (19.78) followed by 0.5% KH_2PO_4 (16.99) and distilled water (16.78) while other treatment had seedling vigour level below the control level (distilled water) whereas seed primed with 4% KCl recorded the lowest value of 10.43. Green fruited seed primed with 1% KH_2PO_4 had the highest seedling vigour value of 16.65, followed by 0.5% KH_2PO_4 (15.42) while seed of green fruit treated with 2% KCl and distilled water had the lowest value of 11.82 and 12.12 respectively.

DISCUSSION

Result from this study indicated that there were significant differences in fruit maturity levels and priming treatments for seed germination, mean germination time, seedling height and seedling vigour index examined. This, therefore, provides opportunity for selection of seeds among the fruit maturation levels and priming treatments with superior seed physiological quality. The interaction effect of priming and fruit maturation level/colours was highly significant on all seed quality traits.

This means that the differences in these quality traits among the fruit maturity levels/colour were influenced by priming treatments evaluated. Farooq *et al.* (2005), Adeshile (2010), Egbeleye (2010) and Adebisi *et al.* (2011a) have reported differential responses among the priming conditions in seed quality traits in different crop species. A study by Adebisi *et al.* (2011a) showed that there were differences in the seed physiological quality among seeds obtained from different fruit maturity levels/colours in gmelina.

On the main effect of chemical priming treatments, seeds from yellow fruit treated with 20% PEG (Polyethylene glycol) had the highest germination percentage, seedling length, seedling vigour index and mean germination time.

Earlier study on fruit colour on *Gmelina arborea* in relation to seed quality pointed out yellow fruit colour with superior seed quality (Adebisi *et al.*, 2011a). In this study, irrespective of fruit maturity colour, seeds of *Gmelina arborea* primed with 0.5% KH_2PO_4, 1% KH_2PO_4 and 20% PEG were found with a distinct and consistent higher seedling germination trait compared with other treatments. Also, the effect of priming with 2% KCl, 4% KCl and 10% PEG was not remarkably different from distilled water treatment for seed germination and seedling vigour index but these treatments gave the lowest mean germination time of between 18-23 days.

Seeds from brown or dark fruits colour have been reported to have poor seed germination traits in *G. arborea* (Adebisi *et al.*, 2011a). Findings in the present study showed that superior seed quality traits were obtained with seeds from yellow and green maturity colours whereas seeds obtained from brown colour had the worse seed quality traits. The poor seed quality from brown fruits may be due to over-ripening of the fruits and subsequent infection of seeds by diseases which destroyed the embryo of the affected seeds.

CONCLUSION

Seeds from fruits of different maturation levels/colours showed considerable differences in seed physiological quality. Seed from yellow fruit treated with 20% PEG (polyethylene glycol) had the highest germination percentage. Priming of seeds with 4% KCl solution resulted in poor emergence in the fruits from the yellow, green and brown colours. This study indicates that seeds from yellow fruits treated with 20% PEG would result in improved high quality seedlings in gmelina forest plantation.

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