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GERMINATION PERFORMANCE OF PRICKED SEEDS AND GERMINATION PATTERN IN *GARCINIA KOLA* (HECKEL)

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ABSTRACT: A study was designed to assess the germination performance of pricked seeds and germination pattern in *Garcinia kola*. Mature fresh fruits of *G. kola* were collected and processed for seed extraction. Seeds were subsequently separated into three (3) pre-germination treatment groups, DP₀, DP₃, and DP₆. Data collected were germination time, daily germination, duration of germination, and total germinated seed. Others were, type of seed, pattern of seed germination, number of seed germinating with radicle, number of seed germinating with plumule, number of seed germinating with plumule and radicle. Germination parameters evaluated were mean germination time, mean daily germination, germination speed, germination capacity, and dormancy period. Normality of data was analyzed using Shapiro-Wilk test. Due to non-normality of germination characteristic data and the similarity of data from DP₃ and DP₆ seed pre-germination treatment, comparison was made between DP₀ and DP₃ using Mann-Whitney test. Seed germination pattern data was analyzed using ANOVA while t-test was used for pairwise comparison. The results showed that *G. kola* seed was monocotyledonous and undifferentiated with hypogeal germination. Pattern of germination was plumule and radicle 70%, plumule only 28%, radicle only 2%. Plumule and radicle emergence differed significantly from plumule only and radicle only germination. Dormancy period (5 days) was shortest in pricked seeds but in control seeds longest (28 days); germination capacity was 100% in pricked seeds and 10% in control seeds; mean germination speed was 1 in pricked seeds but 0.01 in control seeds; mean daily germination was 5 in pricked seeds and 0.06 in control seeds; while, mean germination time was 7 days in pricked seeds and 28 days in control seeds. Pricked seeds differed significantly from the control. Pricking improved the germination performance of *G. kola* seeds however increasing the degree of pricking from 3 to 6 times did not improve germination significantly.

Keywords: Monocotyledonous, hypogeal, bipolar, monopolar, pre-germination treatment

1. INTRODUCTION

Garcinia kola is an indigenous multipurpose fruit tree in Nigeria that thrives in the rainforests of the south (Dadjo *et al.*, 2019). The species is found both in the dry rainforests and the wet/humid rainforests (Okonkwo *et al.* 2020). Recent studies showed that there is genetic structuring and diversity between and within the ecotypes

in the southwest and southeast (Ashiru *et al.*, 2018; Olawuyi and Azeez, 2019). There is therefore a reservoir of germplasm and genetic diversity within the species to be explored for the domestication and improvement of the species in the country (e.g. seed germination improvement). Moreover, this is also important to the adaptation of the species to changing local growing conditions resulting from global climate change.

G. kola seed is by far the most popular and traded product of the tree. *G. kola* is locally used in the treatment of cough, anti-bacterial and other medicinal purposes (Ashiru *et al.*, 2018). *G. kola* seed trade value chain is such that provides supplementary incomes and diversified livelihood activities. Nevertheless, *G. kola* is vulnerable in the wild due to high rate of deforestation and low cultivation (Cheek, 2004). There is therefore the need to improve the cultivation of the species and possibly develop early fruiting cultivars that will encourage farmers to incorporate the tree into local farming systems. Improved cultivation of *G. kola* will ensure the conservation of the species, increased on-farm biodiversity, climate change mitigation through on-farm carbon sequestration and improved rural livelihoods.

For a long time, the idea was that *G. kola* seed was difficult to propagate (Anegbe *et al.*, 2006; Eyo-Matig, *et al.* 2007; Oboho and Ogana, 2011; Yakubu *et al.*, 2014). However, Asomaning *et al.* (2011) investigating the desiccation sensitivity of the seed has demonstrated that the seeds lose capacity to germinate with reducing moisture content like a typical recalcitrant seed. *G. kola* is therefore best propagated from fresh seeds (Gyimah, 2000; Asomaning *et al.*, 2011; Okonkwo *et al.*, 2020).

G. kola seed dormancy has however been reported by several authors (Anegbe *et al.*, 2006; Eyo-Matig, *et al.* 2007; Oboho and Ogana, 2011; Yakubu *et al.*, 2014). Okonkwo *et al.* (2020) and Yakubu *et al.*, (2014) described *G. kola* seed dormancy as both physical (seed-coat dormancy) and physiological (endospermic dormancy) otherwise known as combinational dormancy. Germination of fresh *G. kola* seed can however be enhanced when given the appropriate pre-germination treatment. For example, Gyimah (2000) reported that, soaking in water and hydrogen peroxide induces early start of germination while, warm stratification enhances germination by 40-45 %. Improved germination of *G. kola* seed is important to nursery propagation of the species and availability of seedlings. A study therefore was designed to evaluate the effect of two pricking regimes on the germination of *G. kola* seeds and as an adjunct to assess germination pattern in the species.

2. MATERIALS AND METHODS

G. kola seeds used in the study were collected from the research plots of Swamp Forest Research Station, Onne, Rivers State, Forestry Research Institute of Nigeria. The area is located on latitude 4° 50' N and longitude 7° 03' E. Annual rainfall is 2500mm with a mean value of 75% relative humidity in February and 80% in July. The mean minimum temperature is 25 °C.

Mature fresh fruits of *G. kola* were collected and processed for seed extraction. Seeds were subsequently separated into three (3) treatment groups (Table 1). Seeds were propagated in clear heavy-duty polythene bags 0.1 mm thick and 100 mm x 150 mm dimension at 28°C ambient temperature (Okonkwo *et al.*, 2020). There were 40 seeds per treatment and a total of 120 seeds in all in a completely randomized experimental layout. Seeds were always kept moist by sprinkling with water. Data collected were germination time, daily germination, duration of germination, and total germinated seed. Others were, type of seed germination, number of seed germinating with radicle, number of seed germinating with plumule, number of seed germinating with plumule and radicle. Germination parameters evaluated were:

1. Mean germination speed (MGS): This was calculated using the formula of Gairola *et al.*, (2011) and Kebede and Yidinekachew, (2014):

$$MGS = \frac{n1/d1 + n2/d2 + n3/d3 + \dots}{N} \text{ -- (eq. 1)}$$

Where, n = number of germinated seed, N = number of observations, d = number of days.

2. Mean germination time (MGT): This was calculated as:

$$MGT = \frac{d1 + d2 + d3 + \dots}{N} \text{ -- (eq. 2)}$$

Where, d = germination days, n = number of observations.

3. Mean daily germination (MDG): This is calculated using the method of Czabator (1962); Kebede and Yidinekachew (2014):

$$MDG = \frac{\text{Total number of germinated seed}}{\text{Total number of days}} \text{ (eq. 3)}$$

4. Number of days before first germination (dormancy period). This was the number of days from the sowing date to the first germination.

6. Germination capacity (GC): This was calculated as:

$$GC(\%) = \frac{\text{Number of germinated seed}}{\text{Total number of seed}} \times 100 \text{ -- (eq. 4)}$$

Normality of data was analyzed using Shapiro-Wilk test. Due to non-normality of germination characteristic data and the similarity of data from DP₃ and DP₆ seed pre-

germination treatment, comparison was made between DP₀ and DP₃ using Mann-Whitney test for two independent samples. Seed germination pattern data was analyzed using ANOVA while t-test was used for pairwise comparison.

Table 1. Seed pre-germination treatment methods and description

Treatment	Description
DP ₀	De-coated seeds unpricked and not sprinkled with water nor dropped in water, used as control treatment.
DP ₃	De-coated seeds pricked three (3) times and sprinkled with water at ambient temperature (28°C).
DP ₆	De-coated seeds pricked six (6) sprinkled with water at ambient temperature (28°C).

3. RESULTS AND DISCUSSION

3.1. Germination Pattern

G. kola seed is monocotyledonous (Plate 1). Monocotyledonous means that the seed has just one seed leaf or cotyledon (Dianne, 2018). Seed germination in *G. kola* was hypogeal (Plate 1). This implies that the

growing point is normally submerged under the soil in a situation of direct field sowing or wild germination of the seed (Daniel, 2019). Hypogeal germination is the common germination habit of monocots (Nonogaki and Nonogaki, 2017) and they behave this way to ensure the growing point is protected from damage from browsing animals (Daniel, 2019). Hypogeal germination has also been reported in *Allanblackia floribunda*, another member of the *Clusiaceae* family with a monocotyledonous seed, by Ekeke and Nuga (2016), in a study investigating the effect of mechanical pre-germination treatment on the propagation of the seed of the species. While, Yakubu *et al.* (2014) confirmed that *G. kola* seed germination was hypogeal in a study to assess the influence of water soaking and light on the germination of the seed. The monocotyledonous *G. kola* seed is undifferentiated so that you do not really know where the plumule or radicle is going to emerge from. This is in agreement with Kumar and Rangaswamy (1977) who reported that embryo of *Orobanche aegyptiaca* seeds were undifferentiated into plumule, radicle, hypocotyl and cotyledon. Therefore *G. kola* seeds are better planted on their side than on either of the two ends in order to avoid placing the seed with the plumule emergence side buried in the soil. Alternatively, seeds can be pre-germinated in polythene bags before sowing. This has been demonstrated to be effective in propagating *G. kola* seeds by some authors (Yakubu *et al.* 2014; Okonkwo *et al.* 2020)..



Plate 1. Monocotyledonous *G. kola* seed showing hypogeal germination and mixed germination pattern.

3.2. Monopolar and Bipolar Seed Germination Pattern

Three patterns of germination were observed during the germination of *G. kola* seed viz: plumule and radicle (70%), plumule only (28%), and radicle only (2%) (figure 1). This is in agreement with Kumar and

Rangaswamy (1977) who reported monopolar and bipolar germination in *Orobanche aegyptiaca* and Bareke (2018) who observed that most monocot seeds germinate with plumule and radicle perpendicular to each other. When it was the radicle that emerged first the seed showed bipolar germination pattern where plumule

eventually emerged from the opposite end: while seeds that germinated with plumule first or plumule and radicle were usually monopolar where radicle grew perpendicular to the plumule (Plate 1). However, during the advanced stage of seedling development, it was observed that the seedlings were ultimately monopolar: the root that developed from the radicle perpendicular to the plumule grew into the tap root while the radicle on the opposite side of the seed developed into adventitious roots (Plate 1). Analysis of variance showed that there was a significant difference among the germination patterns of *G. kola* seeds (Tables 2). While, t-test pairwise comparison showed that plumule plus radicle emergence differed more significantly from plumule only and radicle only emergence (Table 3). This is further confirmed by the higher frequency rate of occurrence of plumule and radicle emergence (70%) when compared to plumule only (28%), and radicle only (2%) emergence (figure 1). Since time of seedling emergence correlates with its vigor and competitive advantage (Ellis, 1992) it implies that seeds that show simultaneous plumule and radicle emergence (70% of seeds propagated) are more

likely to demonstrate superior seedling vigor and survival.

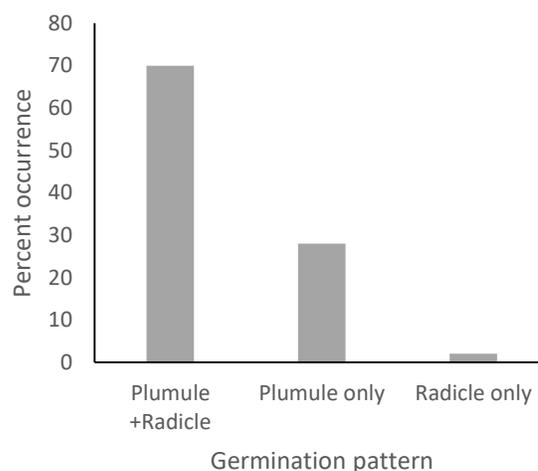


Figure 1. Percent occurrence of germination patterns in *G. kola* seeds.

Table 2. ANOVA of germination patterns in *G. kola* seed

Sources	SS	df	MS	F	P value	Eta-sq	RMSSE	Omega Sq
Between Groups	108.93	2	54.476	36.311	8.13E-06*	0.858	2.695	0.825
Within Groups	18	12	1.5					
Total	126.93	14	9.067					

*= significant at 0.05 alpha value i.e. $p < 0.05$.

Table 3. T-test pairwise comparison of germination patterns in *G. kola*

Group 1	Group 2	p-value	mean
Plumule + Radicle	Plumule only	0.002302*	4.6
Plumule +Radicle	Radicle only	0.000978*	6.4
Plumule only	Radicle only	0.011991*	1.8

*= significant at 0.05 alpha value i.e. $p < 0.05$.

3.3. Germination Performance

Germination performance of the three times pricked seeds was exactly similar to those of the six times pricked seeds (table 4). This shows that three times pricking pre-germination seed treatment was already maximum for *G. kola* seed germination performance improvement over untreated seeds. Dormancy period (5 days) was shortest in pricked seeds, whereas control seeds recorded the longest (28 days); germination capacity was 100% in

pricked seeds and 10% in control seeds; mean germination speed was 1 in pricked seeds but 0.01 in control seeds; mean daily germination was 5 in pricked seeds and 0.06 in control seeds; while, mean germination time was 7 days in pricked seeds and 28 days in control seeds (table 4). Pricking therefore reduced dormancy period and inadvertently increased germination capacity, mean germination speed, and mean daily germination while reducing mean germination time in pricked seeds (table 4). This is in agreement with Okonkwo *et al.* (2020), who while assessing the effect of different seed pre-germination treatment methods on the germination of *G. kola* seeds, discovered that seed dormancy period was inversely related to germination capacity, mean germination speed, and mean daily germination, whereas it is directly related to mean germination time.

Mann-Whitney analysis of germination characteristics showed there was a significant difference between control seeds (DP_0) and pricked seeds (DP_3 and DP_6) (table 5). There was however no significant difference between seeds pricked thrice (DP_3) and those pricked six-

times (DP₆) (table 6). Hence increasing the number of times seeds are pricked did not improve germination performance. However, pricking improved germination performance by increasing the surface area of the seed for immediate water and oxygen absorption and transport to the embryo for the initiation of the germination process (Dianne, 2018). This is in agreement with Okonkwo *et al.* (2020) who reported that pricked *G. kola* seeds recorded better germination performance than intact seeds in an assessment of effect of seed pre-germination treatments methods on the germination of *G. kola* seed. *G. kola* seeds are recalcitrant (Asomaning *et al.* 2011) and unable to withstand long period of storage (Okonkwo *et al.* 2020) and hence suited for propagation from fresh seeds while pricking can be a method to improve the germination.

Table 4. Effect of pricking on the germination characteristics of *G. kola* seeds.

	DP ₀	DP ₃	DP ₆
MGS	0.01	1	1
MGT	28	7	7
MDG	0.06	5	5
GC	10	100	100
DP	28	5	5

Note: MGS = mean germination speed; MGT= mean germination time; MDG = mean daily germination; GC = germination capacity; DP = dormancy period.

Table 5. Mann-Whitney analysis of the germination performance of pricked seeds and control (unpricked) seeds *G. kola* seed.

	DP ₀	DP ₃ /DP ₆
count	5	5
median	2.8	5
rank sum	24	31
U	16	9*
U-critical		42
mean		12.5
std dev		4.772607
z-score		0.628587
effect r		0.198777

*=significant i.e. U-critical >U

Note: DP₀ = decoated unpricked seed (control); DP₃ = decoated seed pricked three times; DP₆ = decoated seed pricked 6 times.

Table 6. Mann-Whitney analysis of the germination performance of three times pricked seeds and six times pricked seeds.

	*DP ₃	DP ₆
count	5	5
median	5	5
rank sum	27.5	27.5
U	12.5	12.5 ^{ns}
U-critical		4
mean		12.5
std dev		4.594683
z-score		0.108821
effect r		0.034412

ns=not significant i.e. U-critical <U

*DP₃ = de-coated seed pricked three times; DP₆ = de-coated seed pricked 6 times.

4. CONCLUSION

From this study, the following conclusions are made:

1. *G. kola* seed is a monocotyledonous seed that is undifferentiated such that it is difficult to really identify visually the pole of emergence of the radicle or the plumule.
2. *G. kola* seed displays both monopolar and bipolar germination behaviour. Germination of the seed was hypogeal and consists of three patterns of germination viz: plumule and radicle (70%), plumule only (28%), and radicle only (2%). The germination pattern plumule and radicle emergence differed significantly from the other two indicating that this germination pattern is more common with *G. kola* seeds.
3. Pricked seeds recorded highest germination capacity, mean daily germination, mean germination speed, and lower mean germination time and dormancy period when compared with the control or untreated seeds.
4. There was no significant difference in germination performance between three times pricked seeds and the six times pricked seeds. Three times pricking was maximum for *G. kola* seed germination improvement. Pricking therefore improved the germination performance of *G. kola* seeds.

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