Journal of Plant Science and Crop Production (JOPS), Vol. 1, 2024: 67-81
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Exploring the Impact of Seed Biotype Color, Scarification Techniques and Intensity on Germination and Growth of Kola Plantlets (*Cola nitida*, Vent. Schott. & Endl.) in the Pre-Nursery

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Abstract
The production of *Cola nitida* nuts has decreased worldwide over time due to its pronounced dormancy period. Experiment was conducted in the screen house at the Federal University of Agriculture Abeokuta to determine the effects of biotype colour, method and intensity of scarification of Kolanut seed on germination and growth performance. It was a 3 × 2 × 3 factorial arranged in a Completely Randomized Design with three replicates. Treatment involved seed biotype colour at 3 levels (white, red and pink), scarification-method at 2 levels (epicarp-scraping and epicarp line-cutting), scarification intensity at 3 levels (single, double and triple epicarp line-cutting and scraping) and the controls (untreated white, pink and red seeds) totaling 21 treatments. Data collected on percentage germination and growth performance were subjected to Analysis of Variance Mean. Results showed that germination of between 3.33% and 6.66% were observed early at 2 WAS in the white kola seeds scraped once as well as pink and red kola seeds cut twice. At 20 WAS, white, pink and red kola seeds scraped once gave germination of between 96.6 and 100% respectively. Seedlings raised from white kola seeds scraped thrice had the tallest plant with height value (37.6 cm) followed by those from red kola nuts scraped once with height value (35.1 cm) relative to same periods after sowing. The study concluded that epicarp of white, pink or red seeds of *Cola nitida*, treated with single, double and triple line-cutting or scraping, resulted into early germination and improved subsequent seedling growth.

Keywords: Dormancy, intensity of scarification, epicarp scrapping, epicarp cutting.

Citation: Boladale, S. B., Hammed, L. A. Olasantan, F. O. and Adebisi, M. A., 2024
Exploring the Impact of Seed Biotype Color, Scarification Techniques and Intensity on Germination and Growth of Kola Plantlets (*Cola nitida*, Vent. Schott. & Endl.) in the Pre-Nursery. Journal of Plant Science and Crop Production (JOPS), 1: 67-81

Introduction

Kola (*Cola nitida*) is a tropical cash crop in Africa that belongs to the family *Sterculiaceae*. The Kola genus comprises of about 125 species (Onomo *et al*., 2006) out of which 50 species have been described in West Africa by Adebola, (2003). In Nigeria, the crop is cultivated mainly in the South Eastern and Western region where it serves as the main livelihood of many farmers and traders. However, the two most common and useful fruit producing species within the genus are *Cola nitida* (Vent.) Schott and Endl. and *Cola acuminata* (P. Beauv.) Schott and Endl. The former being of much more economic importance than the latter (Russell, 1955; Eijnatten, 1973). *Cola nitida* is a popular kola of commerce in Africa probably because it yields most preferable commercial nuts. Kolanuts from both wild and cultivated trees of *C. nitida* are marketed fresh or cured (Burkill, 1961). Kola trade has increased over time since its inception as early as the nineteenth century. It has expanded from the South to the North and from West to the East of the entire West, East and Central Africa (Eijnatten, 1969). Its cultivation has been well established in countries like Carribean Island, Mauritius, Sir-Lanka and Malaysia (Ashiru, 1973). It is distributed in Africa in approximately between latitudes 12^0N and 12^0S of the equator, which covers areas from Senegal to Angola in the West and Tanzania to Mozambique in the East (Van Eijnatten, 1965). They are important economic crops in the forest areas of West and Central Africa, Caribbean Islands, Mauritius, Sri Lanka and Malaysia (Eijinatten, 1969). Although *Cola nitida* is of more economic importance in Nigeria especially in the north, *Cola acuminata* has its origin and is consumed mainly among the Yoruba tribe of Western part of Africa. Kola nut is perhaps second only to oil palm in importance in the list of indigenous cash crops in Nigeria. Its cultivation has been well established in countries other than Africans and these include Caribbean Island, Mauritius, Sri Lanka and Malaysia (Ashiru, 1973). It is grown in Africa in approximately between latitudes 12^0N and 12^0S of the equator, which covers areas from Senegal to Angola in the West and Tanzania to Mozambique in the East (Van Eijnatten, 1965).

According to FAOSTAT (2022), Nigeria produced 174,107 m/t (52.27%) followed by Cote D'Ivoire 58,640 m/t (18.6%), Cameroon 48,570 m/t (15.41 %), Ghana 24,643 m/t (7.82 %), Sierra Leone 8,450 m/t (2.68 %), and Benin republic 611.26 m/t (0.19%), while Chad, had no production, meanwhile, in the Year 2021, the country produced about 5% kolanuts of the total world produc-tion. The use of kola nut, like coffee, tea and cocoa, is of immense benefit in local and industrial application.

Kola nut is an important article of trade in West Africa and in the trans-Saharan trade routes for many centuries (Egbe and Sobamiwa, 1989), a masticatory and herbal stimulant (Herbal Extracts Plus, 2011), and raw material in the manufacture of kola chocolate and kola wine in Cocoa Research Institute of Nigeria (CRIN) (Famuyiwa, 1987). Besides, kola testa has been suggested as a possible fertilizer ingredient (Olubamiwa, 2002). Kola nuts have a high concentration of caffeine which does all of the following: euphoria, physical stimulation (mental alertness), reduce cravings and fatigue, asthma (it enlarges air passage in humans), aphro-disiac, digestion aid, headache and migraine treatment, mild antidepressant, increase energy, relieves diarrhoea, whooping cough treatment, diuretic (causes a person to urinate), and astrin-gent (Nickells, 1986). It refreshes the mouth due to its unique bitter taste, alleviating thirsts, and use of twigs of the kola tree as chewing sticks to clean the teeth and gums (Lewis and Elvin, 1985). Kola has numerous socio-economic as well as nutritional importances. In spite of the immense benefits of kola, some debilitating factors have been limiting its production in Nigeria.

Among these constraints are delayed germination, poor field establishment, poor agronomic practices and ageing kola farms (Adebiyi *et al*., 2011), which led to discourage-ment in cultivation of *Cola nitida* by the farmers and this reduces the supply of nuts to local and international markets. Dormancy is a mechanism that prevents seed germination when expose to suitable conditions that will normally permit emergence of seedling shoots characteristics.

In general, seed dormancy is a qualitative and genetically-inherited trait whose intensity is modified by the environment during seed develop-ment (Adebisi, 2014). However, when seeds need to be planted soon after harvest, removing dormancy is necessary to promote timely and healthy germination. However, little information is available on the efficacy of various treatments in breaking dormancy in *Cola nitida* nut seeds. Successful kola nut establishment depends on the availability of treated quality seeds. Dormancy in seeds may result in poor germination, seedling growth and seedling vigour in many crops. Several studies have been carried out on pre-germination treatment of seeds with the view of overcoming dormancy in such seeds.

These treatments include hydro priming, osmo priming, organic treatment (Adebisi, *et al.*, 2013 a; Adebisi, *et al.*, 2013 b; Ajala, *et al.*, 2008) and mechanical scarification among others. The results of their findings have shown that these treatments improve germina-tion and growth under various conditions compared to their respective control treatments. However, there is dearth of

information on the efficacy of scarification techniques treatment method in breaking the fierce long dormancy in *Cola nitida* nut seeds. Thus, improve studies needs to be carried out on dormancy breaking in Kola research. Therefore, this study was initiated to evaluate the interactive effects of biotype colour, method and intensity of scarification on germination and growth of plantlet in *Cola nitida* species.

Materials and Methods

*Seed material and source***:** Fresh kola seeds of same mother plant (*Cola nitida*) were sourced from a local market in Olugbo Odeda, Ogun State, South Western Nigeria. Seeds/nuts smaller than 20g or infested/infected with insects/ diseased were discarded. Seeds of 20g in weight were used for this study. The seeds/nuts were separated into three biotypic colours – red, pink and white. The experiment was conducted in the screen house of the College of Plant Science and Crop Production, Federal University of Agriculture, Abeokuta, Ogun State Nigeria (Latitude 7^0 15'N Longitude 3^0 25'E) between November, 2014 and June, 2015. The experiment was a 3 × 2 × 3 factorial arrangement laid out in a Completely Randomized Design with three replicates, consisting of seed biotype colour at 3 levels (white, pink and red), method of scarification at 2 levels (epicarp line cutting and scrapping) and intensity of scarification at 3 levels (single, double and triple).

Treatment definition

- Factor-1 includes kola seed biotypes colour at 3 levels
  - White (C_1)
  - Pink (C_2)
  - Red (C_3)
- Factor-2 includes method of scarification at 2 levels
  - Epicarp – line-scrapping (M_1)
  - Epicarp – line-cutting (M_2)
- Factor-3 includes intensity of scarification at 3 levels.
  - Single-epicarp-mark (I_1)
  - Double-epicarp-mark (I_2)
  - Triple-epicarp-mark (I_3)

Thus, there were 18 treatments combination in all plus untreated seeds (control) of each colour biotypes, totalling 21 treatments for the whole experiment.

Fresh sawdust was collected and filled into 50 cl containers which had earlier been punched at 3 points underneath for percolation to allow for excess water drainage. After preparing the seeds in accordance with the treatments, they were sown inside the cups at seeding rate of one seed per cup, horizontally on their sides at a sowing depth of about 4-5 cm. The saw dust was watered to wet for two weeks before planting to allow for partial weathering and moisture percolation in to the medium. Ten seeds were sown per treatment giving 180 seeds per replicate which amounted to 540 treated nuts plus 90 untreated nuts giving a total of 630

nuts for the whole experiment. Watering was carried out daily, early in the morning and evening to prevent the plant from water stress.

Plate 1: Scraping method of scarifying kola seeds

Plate 2: Line-cutting method of scarifying kola seeds

Data collection

Data were collected on:

i. Germination percentage: Counting commenced 2 WAS and was done weekly till no response was observed.
ii. Morphological growth performance of the plantlets:
    - Plant height (cm): Two plants were randomly selected and tagged. Each of the tagged plants was measured from base (on top of the growth medium) to the shoot apex with a meter rule from 16WAS to 22WAS at fortnightly interval.
    - Number of leaves: Leaves on the tagged plants were recorded from 16WAS to 22WAS at an interval of 2 weeks.

- Leaf area (cm^2): The length by breadth of 2 tagged leaves multiplied by 0.72 (Oladokun, 1988) were summed and averaged from 16WAS to 22WAS at an interval of 2 weeks.
- Stem diameter (mm): The diameter of each tagged plant was measured using a Digital Calliper from 16WAS to 22WAS at an interval of 2 weeks.

- Dry matter of shoot and root (g/plant): At 18 and 22 weeks after sowing, one each out of the sampled plants in each of the treatments and untreated was uprooted and rinsed. They were oven dried at temperature of 70^0C and weighed till constant weight was attained.

Data analysis: The data obtained from the experiment were subjected to Analysis of Variance (ANOVA) to determine the level of treatment effects on germination and early growth of kola seedlings using CoStat (CoStat, 1996). Mean separation of the treatments were carried out using Duncan's Multiple Range Test (DMRT) at 5% level of Probability.

Results

At 2 WAS, germination commenced on pink and red seeds cut twice with 6.66% each, followed by white seeds scraped and cut once, pink and red seed cut once and twice with 3.33% each respectively. All other treatments were yet to germinate. At 8WAS, while white, pink and red kola seeds scraped once and white and pink seeds cut once attained more than 50% germination, all other treatments had between 10.0% and 46.6% germination and the differences was significant at $P \leq 0.05$. At 12WAS, white and red kola seeds scraped once attained maximum germination of 96.6% each, all other treated seeds had germination of between 46.6% and 93.3% while germination seeds with control treatment were between 30.0% and 60.0%. At 14WAS, more treated seeds attained their maximum germination percentages. These included white seeds scraped twice (76.6%), white seeds cut thrice (73.3%), red seeds cut once (83.3%). In the control treatments, untreated white, pink and red seeds had germination of 60.0%, 40.0% and 30.0%, respectively. At 20WAS, beyond which no germination was observed, pink seeds scraped once had 100% germination followed by white and red seeds scraped once with 96.6% each, white, pink and red seeds cut twice with germination of 93.3% each, pink seeds cut once and red seeds scraped twice each with 90.0% germination. The treated kola seeds with minimum germination percentages were white and red seeds with 73.3% each while untreated white, pink and red kola seeds had germination percentage of 60.0%, 40.0% and 40.0% respectively (Table 1).

Table 1: Effects of colour, method and intensity of scarification on percentage germination of seeds of *C. nitida* with time in the pre-nursery

	Weeks After Sowing									
Treatments	2	4	6	8	10	12	14	16	18	20
White kola seeds scraped once	3.33a	13.3a	26.6abc	63.3a	90.0ab	96.6a	96.6a	96.6a	96.6a	96.6ab
White kola seeds scraped twice	0.0a	3.33ab	13.3bcd	30.0bcd	50.0c-f	66.6b-e	76.6abc	76.6bcd	76.6abc	76.6bc
White kola seeds scraped thrice	0.0a	0.0b	6.66cd	20.0cd	43.3d-g	70.0a-d	80.0abc	80.0a-d	80.0abc	86.6abc
White kola seeds cut once	3.33a	13.3a	40.0a	56.6ab	73.3a-d	80.0abc	83.3abc	83.3a-d	83.3abc	86.6abc
White kola seeds cut twice	3.33a	6.66ab	10.0bcd	23.3cd	53.3c-f	66.6b-e	86.6abc	86.6abc	86.6abc	93.3abc
White kola seeds cut thrice	0.0a	0.0b	3.33d	13.3d	36.6efg	46.6de	73.3abc	73.3cd	73.3bc	73.3c
Pink kola seeds scraped once	0.0a	6.66ab	16.6bcd	56.6ab	83.3abc	93.3ab	96.6a	96.6a	96.6a	100a
Pink kola seeds scraped twice	0.0a	0.0b	10.0bcd	30.0bcd	63.3a-e	70.0a-d	76.6abc	80.0a-d	80.0abc	83.3abc
Pink kola seeds scraped thrice	0.0a	3.33ab	10.0bcd	30.0bcd	50.0c-f	56.6cde	63.3c	76.6bcd	76.6abc	80.0abc
Pink kola seeds cut once	3.33a	6.66ab	23.3a-d	56.6ab	76.6a-d	76.6abc	83.3abc	90.0abc	90.0ab	90.0abc
Pink kola seeds cut twice	6.66a	10.0ab	20.0a-d	36.6a-d	70.0a-d	83.3abc	86.6abc	93.3ab	93.3ab	93.3abc
Pink kola seeds cut thrice	0.0a	0.0b	3.33d	16.6d	23.3fg	40.0e	73.3abc	73.3cd	73.3bc	80.0abc
Red kola seeds scraped once	0.0a	13.3a	30.0ab	60.0a	93.3a	96.6a	96.6a	96.6a	96.6a	96.6ab
Red kola seeds scraped twice	0.0a	3.33ab	23.3a-d	46.6abc	73.3a-d	83.3abc	86.6abc	86.6abc	86.6abc	90.0abc
Red kola seeds scraped thrice	0.0a	6.66ab	6.66cd	26.6cd	60.0b-e	66.6b-e	70.0bc	76.6bcd	86.6abc	86.6abc
Red kola seeds cut once	3.33a	6.66ab	23.3a-d	46.6abc	76.6a-d	80.0abc	83.3abc	83.3a-d	83.3abc	83.3abc
Red kola seeds cut twice	6.66a	6.66ab	10.0bcd	26.6cd	66.6a-e	76.6abc	90.0ab	90.0abc	90.0ab	93.3abc
Red kola seeds cut thrice	0.0a	0.0b	3.33d	10.0d	16.6g	46.6de	66.6bc	66.6d	66.6c	73.3c

Untreated white kolanuts	0.0a	0.0b	0.0e	30.0bcd	60.0d-g	60.0e	60.0c	60.0e	60.0c	60.0d
Untreated pink kolanuts	0.0a	0.0b	0.0e	20.0cd	30.0efg	30.0ef	40.0cd	40.0e	40.0d	40.0e
Untreated red kolanuts	0.0a	0.0b	0.0e	20 .0cd	30.0fg	30.0f	30.0d	30.0e	40.0d	40.0e

Means with same letter(s), same column, are not significantly different ($P \leq 0.05$).

At 16 WAS, red kola seeds scraped once gave the tallest seedlings value of 33.1cm followed by seedlings raised from white and red seeds scraped thrice with 29.1cm and 28.1cm, respectively. All other treated seeds gave seedlings of between 11.0cm and 25.7cm. Compared to the seedlings raised from red seeds scraped once with tallest seedlings, the seedlings raised from untreated white, pink and red seeds had 44.1%, 83.3% and 65.8% reduced seedling height values and the differences were significant at $P \leq 0.05$. At 18WAS, seedlings raised from red seeds scraped once were tallest with 34.2cm height value. This was followed by white seeds scraped thrice with 31.0cm, red seeds scraped thrice with 29.1cm, white seeds cut twice with 28.7cm, white seeds scraped twice with 28.1cm and pink seeds scraped thrice with 28.0cm. The height of seedlings raised from all other treated seeds was between 13.7cm and 27.6cm. Seedlings raised from untreated white, pink and red seeds had reduced height values to the tune of 43.8%, 78.3% and 65.4% compared to height value of seedlings raised from red seeds scraped once that had maximum value. At 20WAS, white kola seeds scraped thrice had highest height value of 35.9cm followed by red seeds scraped once with 34.8cm, red seeds scraped thrice with 32.5cm, pink seeds scraped once and pink seeds scraped thrice with 31.0cm and 30.3cm, respectively. The height of seedlings raised from all other treated seeds was between 20.7cm and 28.8cm. Seedlings raised from white seeds scraped thrice had height advantages of 45.6%, 68.5% and 65.7% compared to seedlings raised from untreated white, pink and red seeds of *C. nitida*, respectively, in the pre-nursery. At 22WAS, seedlings raised from white seeds scraped thrice had improved height value of 37.6cm followed by red seeds scraped once with 35.1cm and red seeds scraped thrice with 33.3cm height values. The height of seedlings raised from all other treated seeds was between 20.9cm and 31.1cm while seedlings raised from untreated kola seeds had height values of between 12.6cm and 19.9cm. Thus, seedlings raised from white seeds scraped thrice (with highest height value) were 47.0% taller than seedlings raised from untreated white seeds and 66.4% taller than the seedlings raised from untreated pink and red seeds (Table 2).

Table 2: Height (cm) of seedlings of *C. nitida* as affected by biotype colour, method and intensity of scarification of the seeds sown in the pre-nursery

Weeks After Sowing				
Treatment	16	18	20	22
White kola seeds scraped once	23.5abc	23.9abc	25.4abc	26.9ab
White kola seeds scraped twice	25.7ab	28.1abc	28.8abc	29.4ab
White kola seeds scraped thrice	29.1ab	31.0ab	35.9a	37.6a
White kola seeds cut once	23.0abc	25.2abc	26.6abc	26.4ab
White kola seeds cut twice	24.2abc	28.7ab	29.8abc	30.1ab
White kola seeds cut thrice	17.3bc	19.3bc	24.4abc	26.1ab
Pink kola seeds scraped once	24.1abc	27.6abc	31.0abc	30.9ab
Pink kola seeds scraped twice	23.5abc	24.9abc	26.9abc	27.6ab
Pink kola seeds scraped thrice	25.1abc	28.0abc	30.3abc	31.1ab
Pink kola seeds cut once	16.7bc	19.9abc	20.4bc	20.9b
Pink kola seeds cut twice	23.0abc	24.0abc	24.5abc	24.8ab
Pink kola seeds cut thrice	11.1c	17.6bc	20.0c	21.8b
Red kola seeds scraped once	33.1a	34.2a	34.8ab	35.1ab
Red kola seeds scraped twice	22.3abc	23.2abc	23.5abc	24.7ab
Red kola seeds scraped thrice	28.1ab	29.1ab	32.5ab	33.3ab
Red kola seeds cut once	21.7abc	22.4abc	22.7abc	23.2ab
Red kola seeds cut twice	20.3abc	21.7abc	22.8abc	24.5ab
Red kola seeds cut thrice	11.0c	13.7c	20.7bc	23.9ab
Untreated white kolanuts	18.5bc	19.2bc	19.5cde	19.9bc
Untreated pink kolanuts	5.5d	7.4d	11.3de	12.6c
Untreated red kolanuts	11.3cd	11.8cd	12.3de	12.6c

Means with same letter(s), same column, are not significantly different ($P \leq 0.05$).

At 16 WAS, seedlings derived from pink kola seeds cut twice and red kola seeds scraped once produced the highest number of leaves of 10.8 and 10.3, respectively followed by leaves produced by seedlings raised from white seeds cut once (9.6 leaves) and red seeds cut once (9.5 leaves). Seedlings raised from all other treated seeds produced leaves of between 2.0 and 9.0. Compared to the seedlings raised from pink seeds cut twice with highest number of leaves, the seedlings raised from untreated white, pink and red seeds had 58.3%, 62.9% and 62.9% reduced number of leaves. At 18WAS, seedlings derived from pink kola seeds cut twice produced the largest number of leaves (11.8) followed by red kola seeds scraped once (11.6), white kola seeds cut once (11.5) and red kola seeds cut twice (10.8). Seedlings derived from all other treated seeds produced

number of leaves of between 4.0 and 9.8 leaves. Seedlings raised from untreated white, pink and red seeds had 57.6%, 74.5% and 61.8% reduced number of leaves compared to pink seeds cut twice that had highest number of leaves. At 20WAS, Seedlings raised from pink kola seeds cut twice produced the improved number of leaves of 14.1 leaves. This was followed by seedlings raised from white kola seeds scraped thrice, white kola seeds cut once and red kola seeds cut twice. Seedlings from all other treated seeds produced leaves of between 5.3 and 11.5. The untreated white and pink (or red) seeds had reduced number of leaves to the tune of 62.1% and 68.0% compared to pink kola seeds cut twice that recorded the highest number of leaves. At 22 WAS, white kola seeds cut thrice had the highest number of leaves. This was followed by all other treated nut and the differences were not significant at $P \leq 0.05$ (Table 3).

Table 3: Number of leaves of seedlings of *C. nitida* with time as affected by biotype colour, method and intensity of scarification of the seeds sown in the pre-nursery

Weeks After Sowing				
Treatment	16	18	20	22
White kola seeds scraped once	8.0abc	8.3abc	9.5abc	11.0a
White kola seeds scraped twice	6.66a-d	8.1abc	8.6abc	9.6a
White kola seeds scraped thrice	7.0a-d	8.0abc	12.1ab	12.6a
White kola seeds cut once	9.6ab	11.5a	12.1ab	13.3a
White kola seeds cut twice	8.16abc	9.8ab	11.0abc	11.0a
White kola seeds cut thrice	4.5cde	5.6bc	8.6abc	14.5a
Pink kola seeds scraped once	6.5a-d	8.1abc	11.5abc	13.3a
Pink kola seeds scraped twice	7.3a-d	8.6abc	9.8abc	10.8a
Pink kola seeds scraped thrice	6.6a-d	7.8abc	9.0abc	9.0a
Pink kola seeds cut once	5.3b-e	7.5abc	8.5abc	8.8a
Pink kola seeds cut twice	10.8a	11.8a	14.1a	14.0a
Pink kola seeds cut thrice	3.0de	5.5bc	7.3bc	8.3a
Red kola seeds scraped once	10.3a	11.6a	11.6abc	12.6a
Red kola seeds scraped twice	7.8abc	8.5abc	9.5abc	10.5a
Red kola seeds scraped thrice	6.5a-d	9.5ab	10.5abc	11.1a
Red kola seeds cut once	9.5ab	9.8ab	10.0abc	10.3a
Red kola seeds cut twice	9.0abc	10.8a	11.8ab	13.3a
Red kola seeds cut thrice	2.0e	4.0c	5.3c	8.5a
Untreated white kolanuts	4.5de	5.0bc	5.5c	6.0bc
Untreated pink kolanuts	4.0de	3.0c	4.5c	4.5c
Untreated red kolanuts	4.0de	4.5bc	4.5c	4.5c

Means with same letter(s), same column, are not significantly different ($P< 0.05$).

At 16 WAS, seedlings derived from white kola seeds scraped thrice had the highest mean dry matter yield with (14.0g). This is followed by seedlings raised from white seeds cut once (12.2g), white seeds cut twice (10.4g), pink seeds scraped thrice (9.63g), white seeds cut thrice (9.23g) and pink seeds scraped twice (9.16g) respectively. Seedlings raised from all other treated seeds had mean dry matter yield of between 6.4g and 8.30g. The untreated white, pink and red seeds had 78.5%, 62.8% and 50% low dry matter yield compared with white seeds scraped thrice at p≤ 0.05. At 22 WAS, seedlings derived from red kola seeds scraped once and red seeds scraped twice had the highest dry matter yield of (16.7g and 16.5g). this was followed by red seeds cut once (15.3g), red kola seeds cut thrice (14.6g), pink kola seeds cut thrice (14.5g), white seeds scraped twice(14.3g) and pink seeds scraped thrice (14.2) respectively. Seedlings derived from all other treated seeds produced dry matter yield of between 7.8g and 14.1g. Seedlings derived from untreated white, pink and red had 58.6%, 61.0% and 55.0% relative to red seeds scraped thrice and (Table 4).

Table 4: Dry Matter of seedlings of *C. nitida* as affected by biotype colour, method and intensity of scarification of the seeds sown in the pre nursery

Weeks After Sowing		
Treatment	18	22
White kola seeds scraped once	7.96a	11.0abc
White kola seeds scraped twice	6.86a	14.3abc
White kola seeds scraped thrice	14.0a	8.33bc
White kola seeds cut once	12.2a	9.59abc
White kola seeds cut twice	10.4a	12.1abc
White kola seeds cut thrice	9.23a	11.0abc
Pink kola seeds scraped once	7.9a	8.5bc
Pink kola seeds scraped twice	9.16a	12.6abc
Pink kola seeds scraped thrice	9.63a	14.2abc
Pink kola seeds cut once	6.36a	7.8c
Pink kola seeds cut twice	6.96a	8.26bc
Pink kola seeds cut thrice	8.3a	14.5abc
Red kola seeds scraped once	6.93a	14.1abc
Red kola seeds scraped twice	7.93a	16.5a
Red kola seeds scraped thrice	8.23a	16.7a
Red kola seeds cut once	7.4a	15.3ab
Red kola seeds cut twice	6.4a	13.2abc
Red kola seeds cut thrice	8.0a	14.6abc
Untreated white kolanuts	3.0b	6.9d
Untreated pink kolanuts	5.2b	6.5d
Untreated red kolanuts	7.0a	7.5cd

Means with same letter(s), same column, are not significantly different (P≤ 0.05).

Discussion

Germination of *C. nitida* usually takes long time, sometimes up to one year to reach a reasonable percentage. Mechanical hindrance has been implicated for delay in germination of *C. nitida* (Ibikunle and Mackenzie, 1975). Breaking this mechanical barrier allows better respiration with concomitant physiological activities. Removal of testa, scarifying of the cotyledons or breaking the adhesive force that held the two cotyledons together will remove the mechanical barrier and enhance germination (Ibikunle and Mackenzie, 1974). The breaking of the *nitida* effect by way of scarifying the cotyledons which form the basis for this research work was a success. Generally, *Cola nitida* is known to possess post-harvest dormancy due to its high content of alkaloid chemical compound. However, with the aid of scarification method and intensity, it took the treated white, pink and red coloured nut lesser time to overcome their dormancy, because of the fast rate at which imbibitions of water took place, which instigated the endogenous chemical reaction and allowed for rapid mobilization of the nutrient reserve in the cotyledon to facilitate early germination response of the seed. It was observed that germination occurred at 2 weeks after sowing for treated white, pink and red biotype nuts, where pink and red kola seeds cut twice recorded the highest percentage germination, but, not significantly different from other treated seeds. While the untreated white, pink and red coloured nut were yet to germinate. This is in contrast with the report of Oladokun (1998), that white seeds germinated earlier, followed by pink and red nuts in that order. This was verified in this study whereby no germination was observed for the untreated white pink and red kolanuts at 2 weeks after sowing, whereas treated white, pink and red kola nut had rapid germination response respectively. Amongst the complex chemical compound (alkaloid) present in kola nut, the polyphenol concentration is suspected for the fiercely long dormancy.

Literature has shown that polyphenol present in kolanut makes it more astringent than Garcinia kola and *Cola acuminata*. Also, polyphenols makes amino acids unavailable by binding strongly to them (Elias and Bressani, 1979). Polyphenol oxidase activities was discovered to be higher in white *Cola nitida* (Prohp *et al.*, 2009), an enzyme which catalyses polyphenol oxidation reaction. Mobilization of reserves has been described as an important process that controls germination (Eastmond *et al.*, 2000). In particular, mobilization of nitrogen reserves as a source of energy and nutrients to supply expanding new tissues is proposed to take part in the control of germination but, polyphenols might have binded strongly to them. Despite using fresh nuts that underwent

scarification methods and intensity in this study, Van Eijnatten (1967) observed that the embryos of stored *Cola nitida* nuts are much more developed than those of freshly harvested nuts and the basis for rapid germination. However, this study has shown that irrespective of stored nut or fresh nut, germination occurred as early at 2 weeks after sowing with the treatment applied. Also, regardless of nut colour at 8 weeks after sowing, 50% or more germination was obtainable for cotyledon scraped and cut once. Though, Oludemokun (1979) reported that under favourable conditions, *Cola nitida* germinate within 80 days and Van Ejinatten (1964) reported that 50% germination can be attained between 40-50 days when seeds have been pre-germinated in seed boxes, but in this study, at 8 weeks after sowing i.e. 56 days after sowing, more than 50% germination was obtained under the screen house condition irrespective of nut colour.

As mentioned earlier, the concentration of alkaloids compound is suspected for the post harvest dormancy possessed by *Cola nitida*, thus, scarification method and intensity must have reduced the concentration of compound in two ways; firstly, the epicarp layer of the nut must have open which made the endogenous inhibiting hormone (complex compound) oxidized and hydrolyzed to form simple substance as a result of exchange of gases at the interface. Secondly, when the nuts were scraped or cut, which was in form of incise, exposing larger surface area of the tissue to intermittent watering morning and evening, the alkaloid were probably eroded gradually. The untreated nuts were able to compete with some kola seeds cut thrice in germination, probably due to imbibition of too much water because of the larger wounded area which might possibly slow down the germination process. Colour inheritance in kola is rather complex. It is suspected to be under the control of several genes which interplayed (Oladokun, 1988). Probably there is a relationship between the genes for colour and genes for growth. Comparing scarified nuts or scarification method and intensity to un-scarified nuts, the difference in their growth performances were significant. In fact scarified nut performed excellently well than un-scarified nuts throughout the experiment. Though, throughout the experiment, cutting method of scarification had low growth performance, but scraping method competes well with un-scarified nut throughout the experiment.

Conclusion and Recommendation

Under similar conditions, white kola seeds scraped once and pink kola seeds scraped once germinate faster than red kola seeds scraped once. Pink kola seeds scraped once attain 100% germination. Seedlings derived from white kola seeds scraped thrice grow more vegetative at the pre-nursery. Surface scraping of kola nuts induces germination higher than

line-cutting which in turn is better than the control. Single intensity of scarification of kola nut surface induces germination higher than double and triple while control (intact nuts) induces germination least. Kola nut colour, scarification method and intensity of scarification interacted to induce germination to the tune of 96.6% – 100%. White kola seeds scraped once and thrice and pink kola seeds scraped once and thrice should therefore be recommended for early germination of kola seeds and growth performance. For pre-nursery establishment, surface scraping and epicarp line cutting is recommended in place of control (untreated nut) for mass production of kola seedlings. Regardless of nut colour, kola nuts should therefore be scraped once or singly for improved germination and subsequent seedling growth.

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