GERMINATION STUDIES ON *Cola acuminata* (P. BEAUV) (SCHOTT AND ENDLICHER)[1] / —

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Resumen

Se realizó una serie de experimentos para estudiar la germinación de las semillas de Cola acuminata *(P. Beauv) (Schott y Endlicher). Se encontró que las semillas almacenadas germinaron más rápido que las frescas y que el peso de la nuez, el número de cotiledones por nuez y su interacción influyeron significativamente en la germinación. El color de la nuez no afectó significativamente la germinación aunque las nueces rosadas germinaron más rápido que las blancas. El mejor ámbito de temperatura para la germinación fue de 25 a 35°C.*

Introduction

Germination in kola nuts is influenced by numerous factors. Maturity status of the nuts when harvested influences germination of *C. nitida* as immature nuts germinate poorly compared to fully matured nuts (2). Stored *C. nitida* nuts have been found to germinate better and faster than fresh ones (1, 7, 13). This storage advantage operates irrespective of pre- or post-sowing treatments.

Effect of colour on germination of *C. nitida* nuts has been reported by van Eijnatten (6) who stated that white nuts usually germinate quicker than the red nuts. *C. acuminata* nuts also occur in red, pink and white colours but the relative influence of colour on their germination has not been reported.

The effects of the environmental factors of light and temperature have not been investigated in detail. Reports of the effects of light on germination of *C. nitida* are conflicting. High temperature, i.e. above 35°C is detrimental to germination of *C. nitida* nuts (1, 3, 7) while continuous temperature of 30°C gave the best results (13). No known record exists on the effects of the foregoing factors on germination of *C. acuminata*.

Nut weight is another factor which has been found to influence germination of both *C. nitida* and *C. acuminata* nuts. While Clay (3) and van Eijnatten and Quarcoo (8) found no significant effect of nut weight on germination of *C. nitida* but Ashiru (1), Dublin (4), Ibikunle and MacKenzie (13) reported an increase in germination with increases in nut weight. However, the role of nut weight *per se* in the earliness of germination becomes questionable with the report of Brown and Afrifa (2) that cutting off about half of the *C. nitida* nut accelerated germination of the cut nuts ahead of the whole nuts although it led to some delay in initial growth after germination.

Unlike *C. nitida,* the nuts of which have two cotyledon (occasionally one or three), *C. acuminata* nuts generally have two to six cotyledons but sometimes one or seven cotyledons (14). Variability in cotyledon number has however been found to influence germination (12), the fastest germinating nuts are those with four or five cotyledons.

This paper reports the findings on the effects of storage, nut weight, and cotyledon number, nut colour and temperature on germination of *C. acuminata* nuts.

Materials and methods

The sowing medium for all the germination trials reported herein was wet sawdust in germinating trays measuring 122 x 122 x 15 cm except for the trial

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designed to study the temperature effect on germination which was carried out in cooled Gallenkamp incubators. The trays were covered with a transparent polythene sheet of 0.062 mm thickness to conserve moisture. Watering was done from time to time as the need arose. Daily records of seedling emergence were kept except in the temperature trial where a nut was regarded to have germinated with the emergence of the radicle. Median time (Tm), the number of days required to obtain fifty percent germination, was recorded and was used to evaluate the rate of germination of the nuts.

Storage and nut weight

Nuts purchased in Ibadan (Oja Oba) and fresh ones from the rural areas in Oyo State were sorted out into nut weight classes as follows: 1-5, 6-10, 11-15, 16-20, 21-25, 26-30 and 31-35 g. They were then sown in the germinating tray at the rate of 10 nuts per nut weight class. There were five replicates for each nut weight class in both stored and fresh nut trials. These were laid out in a randomised complete block design. Each experiment was run twice.

Nut weight and cotyledon number

The nuts were sorted into nut weight classes as reported above. Each nut weight class was also sorted out into various nut cotyledon number classes. Effect of these two factors was simultaneously tested in a factorial trial of 1-5, 6-10, 11-15, 16-20, 21-25, 26-30 g size at 2, 3, 4 and 5 cotyledon number combinations. There were 10 nuts per replicate and a Randomised Complete Block design was used. The experiment was run twice.

Nut colour

Fresh 16-20 g weight nuts were sorted out into red, pink and white colours. Ten nuts of each colour were sown per replicate. Five replicates were used in the first trial but owing to insufficient experimental material, only four replicates were used in the repeat trial. The first trial was run at the nursery of the Cocoa Research Institute of Nigeria, Gambari Experimental Station, Ibadan, while the repeat trial was done at the green house of the Agricultural Biology Department of the University of Ibadan. Randomisation in both trials was in Graeco Latin pattern.

Temperature

Ten four-cotyledon nuts weighing 10-20 g were randomly selected and put in a transparent polythene bag of 0.025 mm thickness. Twenty-eight of these bags were numbered. Seven different treatment investigated in cooled Gallenkamp incubators model N. IH/287 were 10, 15, 20, 25, 30, 35 and 40°C. Into each polythene bag water was sprayed to wet the inside using a hand sprayer (45 strokes for each bag) and each bag was sealed with cellotape. The bags were randomly distributed among the treatment at the rate of four replicates per treatment. Each bag was opened once a day for one hour to allow aeration and water supply as necessary. The experiment was run twice.

Results

Storage and nut weight

Nut weight effect was significant on the germination of both the fresh and stored nuts (Figure 1). Thus 16-20 g and 21-25 g nut weight classes germinated best in the fresh nuts while the poorest nut weight class was 31-35 g weight. In the stored nuts, 11-15 g nut weight class led others.

The rate of germination tended to increase with nut weight though not consistently (Figure 2). Hence there was a gradual increase in the rate of germination of the fresh nuts with increase in nut weight up to 21-25 g nut weight class while it started to decrease as from 26-30 g nut weight class. Similarly, there was a increase in the rate of germination of stored nuts up to 11-15 g nut weight class only to start decreasing as from 16-20 nut weight class.

The stored nuts germinated earlier and faster than the fresh nuts. This is evidence by greater median time with the fresh nuts than with the stored nuts (Figure 2).

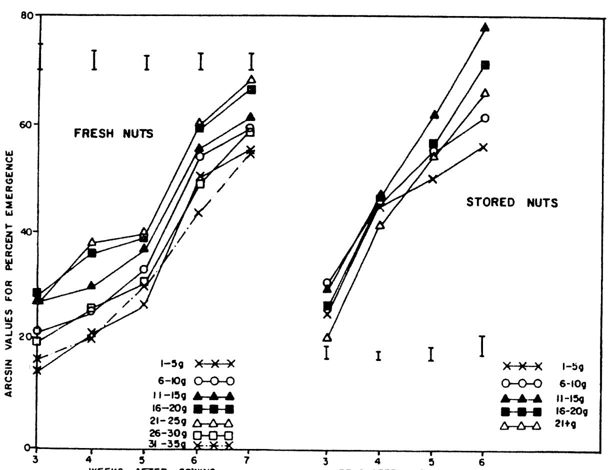

Fig. 1. Effect of nut weight on germination of *Cola acuminata* nuts. Bars represent standard errors.

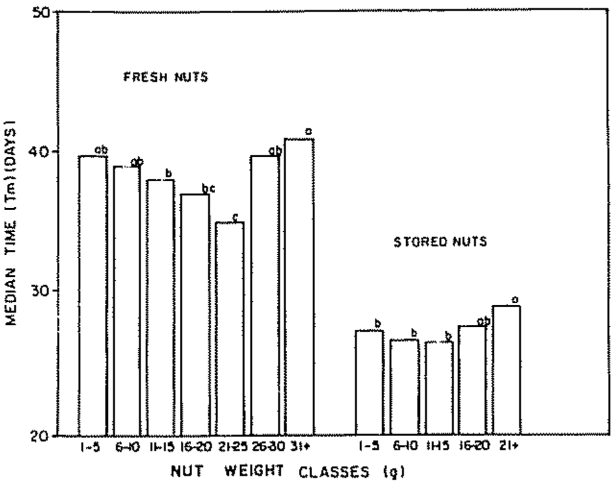

Fig. 2. Nut weight and median time of germination in *Cola acuminta*

Nut weight and cotyledon number

Both the nut weight and nut cotyledon number influenced the germination of *C. acuminata* nuts as main factors in a factorial trial on the effect of nut weight and nut cotyledon on the germination of *C. acuminata* nuts. The interaction between both factors was also significant ($P = 0.001$) (Table 1).

Figure 3 shows the interactive effect of both the nut weight and nut cotyledon number on germination of *C. acuminata* nuts. The 2-cotyledon nuts failed to germinate in the first three weeks after sowing irrespective of nut weight but germination occurred in 3-, 4-, and 5-cotyledon nuts. Subsequently, germination occurred in 2- cotyledon nuts as well. The spread of curves and order of the various nut weight classes vary with nut cotyledon number. In 2-cotyledon nuts, the germination of 1-5, 6-10 and 11-15 g nuts were not significantly different from one another but were significantly different from other nut weight classes, the latter also not being significantly different from one another. In 4- cotyledon

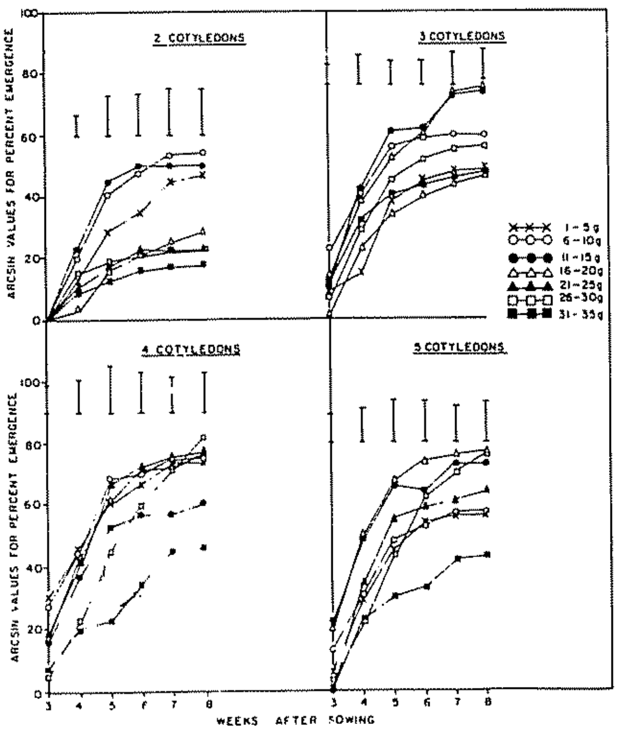

Fig. 3 Effect of nut weight and cotyledon number on germination of *Cola acuminata* nuts. Bars represent standard errors.

nuts, those in the 1-30 g weight range were not significantly different from one another in germination while 31-35 g nuts germinated poorest. The same variation as reported for 4- cotyledon nuts repeated itself in 5- cotyledon nuts except that the spread of the curves was more than was obtained in 4-cotyledon nuts.

Figures 4 and 5 show the pooled nut weight and nut cotyledon number effects. The pooled nut weight effects showed that there were three groups of nut weight effects on germination. The first – group comprised 6-10, 11-15 and 16-20 g nuts while the second group was made up of 1-5, 21-25 and 26-30 g nuts. The third and last group was that of

Table 1. **Mean square values for the effect of nut weight and nut cotyledon number on germination of *Cola acuminata* nuts.**

Sources of variation	DF	Weeks after sowing		
		3	5	7
Block	9	236.85*	430.01*	565.77*
Nut wt.	6	887.87*	3 493.46*	2 786.17*
Cot. No.	3	3 722.31*	11 421.05*	15 114.67*
Nut wt. x Cot. No.	18	414.54*	973.54*	1 118.30*

* Significant at 0.1%.

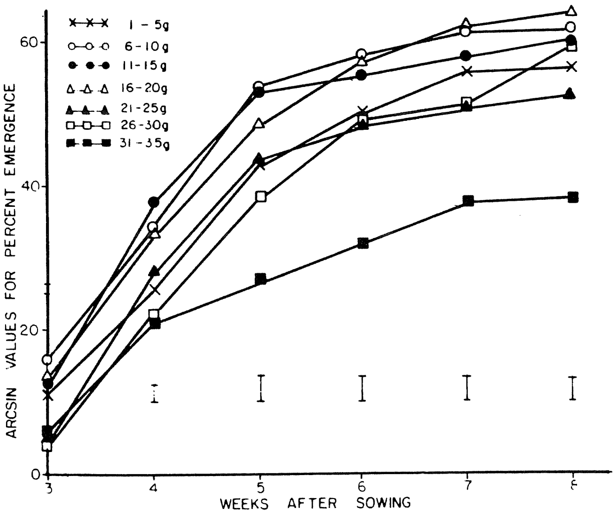

Fig. 4. Pooled nut weight effect on germination of *Cola acuminata* in nut weight: nut cotyledon number factorial trial. Bars represent standard errors.

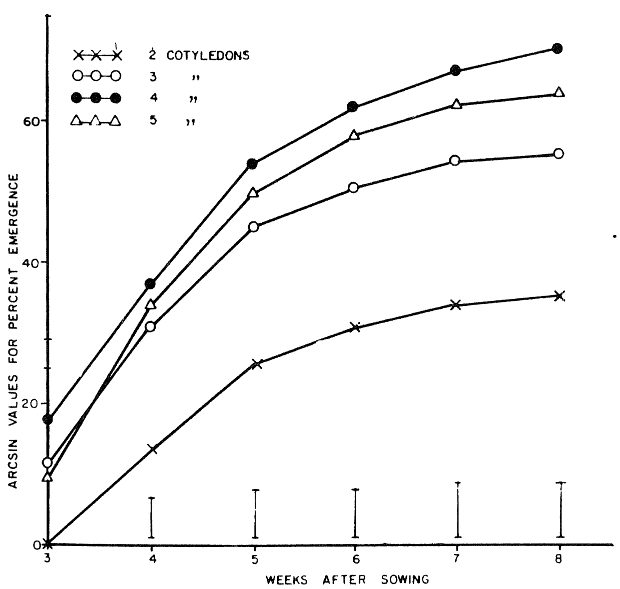

Fig. 5. Pooled cotyledon effect on germination of *Cola acuminata* in nut weight: nut cotyledon number factorial trial. Bars represent standard errors.

31-35 g nuts. Although the first group was slightly ahead of the second group, the two were not significantly different from each other. The two were, however, significantly different from the third group which recorded the poorest germination. On nut cotyledon number, the trend of germination performances of the various nut cotyledon number was 2-, 3-, 5- and 4- cotyledon nuts in the increasing order of magnitude (Figure 5). The 2- cotyledon nuts significantly germinated poorer than other nut cotyledon numbers.

Nut colour

Pink nuts germinated best followed by the red nuts as shown by the rate of germination depicted by the median time (Tm) values in Table 2. On percentage germination basis, pink nuts led the other two colours until the sixth week after sowing when the red nuts took the lead (Figure 5). White nuts germinated poorest as evidenced by both the least overall germination percentage and slowest rate of germination.

Table 2. Median time (Tm) values of germination of *Cola acuminata* nuts as influenced by nut colour.

Nut colour	Tm (days)
Red	28.90 ab*
Pink	26.50 b
White	33.00 a

* Each figure is the mean of eight replicates. Values with same letters are not significantly different at $P = 0.05$.

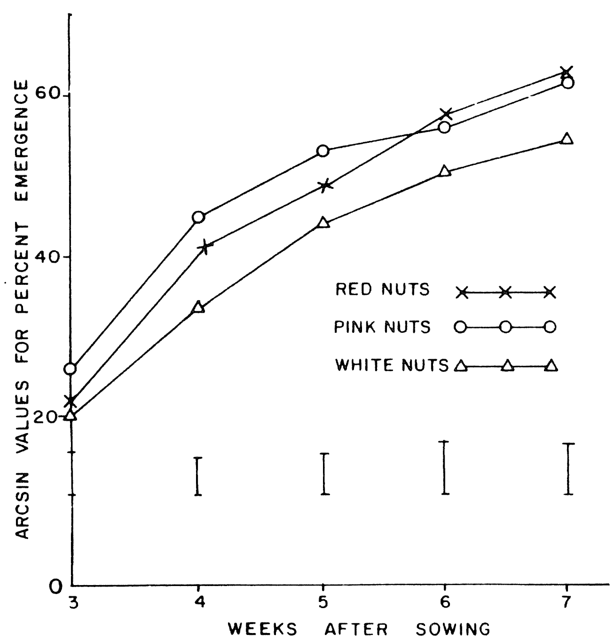

Fig. 6. Effect of nut colour on germination of *Cola acuminata* nuts. Bars represent standard errors.

Temperature

The best temperature for the germination of *C. acuminata* nuts was between 25°C and 35°C (Table 3). The minimum temperature was between 15° C and 20°C while the maximum was between 35°C and 40°C Nuts sown under 10°C and 15°C failed to germinate throughout the five – week period of observation. They however germinated within the first week of transfer to higher temperature (20°C and 30°C respectively) (Table 4) Nuts sown under 40°C temperature were heat – dehydrated

Discussion

Storage and nut weight

Reports of Ashiru (1), Dublin (4), Ibikunle and MacKenzie (12) on the improvement in germination with increase in nut weight of *C. nitida* and the fact that 11-15 g nut weight class recorded the best germination velocity in *C. acuminata* (12) agreed well with the outcome of the germination trial on fresh *C. acuminata* nuts and especially the outcome of the same trial on the stored nuts where 11-15 g nut weight class recorded the highest overall percentage germination (Figure 1) In fact, Ibikunle (12) suggested that nuts whose weight fall within the range of 16-20 g nut weight be sown to combine the advantage of speed of germination and some degree of vigour of seedling development because as reported by Oladokum (14), nut weight influenced growth and development of *C. acuminata* seedlings

The better performance of the stored nuts compared to the fresh nuts in germination have been reported for *C. nitida* by van Eijnatten (5, 6), Clay (3), Ashiru (1), Ibikunle and MacKenzie (13) and they all agreed with present findings on *C. acuminata*. These comparative differences in the germination of both fresh and stored *C. acuminata* nuts could be due to two reasons. One is the changes in nut moisture content whose percentage will be less in the stored than in the fresh nuts. Oladokun (14) reported that nut moisture content correlated negatively with nut weight in *C. acuminata* and *C. nitida*. As it is known that nut weight correlated positively with germination performance of kolanuts, it can be adduced that reduced moisture content in stored *C. acuminata* nuts probably led to better germination performances over the fresh nuts Secondly, van Eijnatten (6) discovered that the embryos of stored *C. nitida* nuts were much more developed morphogenetically than those of the fresh nuts.

Table 3. Effect of temperature on the germination of *Cola acuminata* nuts (Arcsin transformed values of percentage germination).

Temperature	Period after sowing (weeks)					
	1	2	3	4	5	Tm
10	0b	0c	0d	0c	0c	
15	0b	0c	0d	0c	0c	
20	9 21b	23 44b	42.70c	55 70b	62.03b	22.50
25	6 91b	41 33a	56 89b	68 14a	68.14ab	18 40
30	19 18ab	52 74a	67 58 a	74 79a	74 79a	12.00
35	21 41a	50.52a	62 83ab	70 26a	70 26a	12 70
40	0b	0c	0d	0c	0c	

* Each figure is the cumulative mean of eight replicates, each replicate beign made up of 10 nuts. Values with the same letters within the column are not significantly different at P = 0 05.

Table 4. Germination of *Cola acuminata* nuts transferred from 10°C and 15°C to 20°C and 30°C respectively.

Temperature	Period after transfer (weeks)			
	1	2	3	4
20	22.61 ± 6 78	41.19 ± 2 98	56 71 ± 4 04	58 18 ± 3.09
30	51 00 ± 2.98	63.24 ± 2 64	70.55 ± 0 95	73 87 ± 2 15

* Each figure is the cumulative mean of eight replicates, plus or minus standard error, each replicate being made up of 10 nuts Nuts from 10°C were transferred to 20°C, and those from 15°C transferred to 30°C.

This is also true of *C. acuminata* under storage conditions as the majority of *C. acuminata* nuts do germinate while in storage.

Nut weight and cotyledon number

Working on the effect of nut cotyledon number on germination of *C. acuminata* nuts irrespective of weight, Ibikunle (12) reported that the highest percentage germination was obtained from the nuts with the highest number of cotyledons (i.e. 4- and 5- cotyledons), the percentage germination falling with decreasing number of cotyledons. These findings were confirmed in this study (Figure 5).

The interaction between the nut weight and nut cotyledon number on the germination of *C. acuminata* nuts however calls for some comments. It is obvious that whatever the promotive influence increasing nut weight may have on the germination of *C. acuminata* nuts, the interference of the specific number of cotyledons of the nuts will operate. The nature and the degree of such interference will be determined by the degree of the variation of the nut cotyledon number within the given population of the nuts. As can be seen from Figure 5, the more the 2- cotyledon nuts, the more will be the intensity of the repressive effects of nut cotyledon number on germination of the nuts. It is however interesting to note that in a study carried out to investigate the frequency of each cotyledon number, 4- cotyledon nuts, followed by 5- cotyledon nuts, outnumbered all other types of nuts (14) while 2- cotyledon nuts were relatively fewer.

However, these results seem to introduce another element to the question of the relative germination characteristics of *C. nitida* and *C. acuminata*. Can the delay in germination of *C. nitida* be due to the fact that it has two cotyledons while *C. acuminata* has several? Much as one may be tempted to advance a positive answer to the question, on the basis of these results, reasons abound why the cotyledon number effect may not be implicated. First, post-harvest dormancy is a common phenomenon in several seeds, both of dicotyledon and monocotyledon plants. Secondly and perhaps more importantly, *C. lepidota* belongs to the same genus (*Cola*) as *C. nitida* and *C. acuminata*. Though it has two cotyledons as *C. nitida*, its nuts germinate within a day or two of removal of testa. Thus the question of dormancy of *C. nitida* nuts may yet be looked at from the physico-chemical status of the entire nut. Ibikunle (12) explained the improved germination of *Cola acuminata* nuts with increase in the number of nut cotyledons to be due to decrease in adhesive force holding the cotyledon together as their number increased. Thus the poor germination performance of the 2- cotyledon nuts was due to a high adhesive force holding the two cotyledons together that created a physical barrier in the way of the embryos. This he called "nitida effect" (12).

Overall, a compromise will need to be made between the rate of germination and subsequent seedling growth and development before deciding on which nuts to use in raising nursery stocks. Heavier nuts support the seedlings better than higher ones in the early stages of growth and development. On the other hand, nut cotyledon number plays some determinant effect on germination of *C. acuminata* nuts. Thus in modifying Ibikunle's recommendation (12), it will be advisable to choose medium sized nuts (11-25 g) having 4- or 5- cotyledons for raising *C. acuminata* seedlings.

Nut colour

The order of germination performance for the three colours was pink, red and white nuts in decreasing order of magnitude for the first five weeks after sowing. As from the sixth week, this order altered to red, pink and white nuts in decreasing order of germination. However, the differences among the colours in both percentage germination and median time values were not significant though white nuts germinated slower than the pink. These results contradicted the report of van Eijnatten (10) that white nuts usually germinate quicker than red nuts in kola.

The better germination performance of the pink nuts to other colours must be examined against the frequency of occurrence of the three colours within a given population of *C. acuminata* nuts. Oladokun (14) reported that pink nuts recorded the highest frequency (64%) among the three colours in a population of 29 428 nuts while white nuts recorded the least (3.4%). Thus it can be suggested that nut colour distribution in *C. acuminata* may be linked with germination and perhaps subsequent growth performance. Such linkage may be genetic. van Eijnatten (9) stated that white nut is recessive to the red nut while the latter is recessive to the pink nut in kola. Thus the influence of genetic colour dominance was manifested in germination ability and was reflected understandably in natural selection.

Temperature

Using both the median time values and percentage germination bases, the best temperature range for germination of *C. acuminata* nuts was 25-35°C. This finding compared favourably with the findings of van Eijnatten (7) that 30°C gave the best germination followed by the room temperature in *C. nitida*. He also found that continuous temperature of 37°C killed all the nuts, an observation which was repeated by 40°C in this study. Ashiru (1) also reported that high temperatures were detrimental to the germination of *C. nitida* nuts while Ibikunle and MacKenzie (13) found 30°C to give the best result in *C. nitida*. Ibikunle (11) found 35°C to be lethal to the germination of *C. nitida*, a report contrary to the present finding on *C. acuminata*. This difference means that *C. acuminata* nuts are probably more heat – tolerant than *C. nitida* nuts.

The fact that nuts sown at 10°C and 15°C did not germinate showed that 20°C would be about the minimum temperature for the germination of *C. acuminata* nuts. However, it is interesting to note that when the temperatures were raised to 20°C and 30°C respectively, germination commenced. Thus beside the fact that the initial treatment had not nullified the germination potentiality of the nuts, the embryos remained dormant until the ideal range of temperature was provided. This was unlike the case of 40°C where the embryos were most probably killed (that is, irreversibly "inactivated").

Conclusions

The present study shows that when raising *C. acuminata* seedlings efforts must be made to select relatively medium sized nuts (11-25 g) and with four or five cotyledons. Unless, they are particularly needed, white nuts should be less preferred than red or pink nuts. The nuts should be sown in a medium temperature of 30°C-35°C.

Summary

Series of experiments carried out on germination of *Cola acuminata* nuts showed that stored nuts germinated faster than fresh nuts; nut weight and nut cotyledon number and their intraction influenced germination of the nuts. Nut colour effect was not significant on germination but pink nuts germinated quicker than the white nuts. The best temperature range for germination of the nuts was 25-35°C.

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Reseña de libros

J E FERGUSSON Inorganic chemistry and the earth Pergamon Press; Oxford: 1982

La química es la ciencia que estudia las propiedades y los cambios de los elementos, junto con las relaciones energéticas que los acompañan, en estrecha relación con las actividades básicas del hombre Cualquier disciplina científica que estudie los fenómenos y problemas ambientales de la tierra recurre hoy día a la Química como medio de estimar y cuantificar los procesos de la naturaleza y su dinámica Es evidente que la Química se ha integrado a todas las disciplinas que estudian el ambiente y es fundamental su contribución, en grupos interdisciplinarios

El libro "Inorganic Chemistry and the Earth" es un magnífico punto de referencia para los estudiosos de problemas ambientales de la tierra Su enfoque, conciso y de mucha cobertura, presenta a la Química Inorgánica en el contexto del medio con énfasis en su componente físico pero relacionándolo con el componente biológico y con los problemas y necesidades de la sociedad moderna Está escrito con un estilo sencillo y directo, que va, sin mucho preámbulo, describiendo los hechos con ayuda de gran cantidad de cuadros, esquemas y gráficas

Esta obra está dividida en cuatro partes La primera trata del origen de los elementos químicos y de la tierra, de su estado actual y los principales cambios y reacciones que afectan a los componentes de la tierra en términos de sus grandes sistemas: la atmósfera, la hidrósfera y la litósfera

La segunda parte trata de los recursos minerales y sus fuentes, su formación y métodos de extracción, relaciones energéticas con el rendimiento de la producción y consumo; los recursos energéticos, su composición y utilización, yendo desde la energía nuclear hasta la fotosintesis y las celdas de energia

La tercera parte la dedica el autor al estudio de algunos procesos químicos involucrados en la producción de sustancias químicas de uso diario y su importancia en la industria moderna

La cuarta parte es la más extensa, abarca toda la segunda mitad del texto y se ocupa enteramente de las consecuencias de la actividad humana sobre el ambiente al utilizar los recursos minerales, todo dentro del marco de las principales regiones habitables del planeta, la hidrósfera, la atmósfera, la litósfera y la biósfera, de la interacción y transporte de las sustancias químicas entre esas regiones, principalmente a través de los ciclos biogeoquímicos Esta cuarta parte trata además y de manera sectorial, los fenómenos de la contaminación, las fuentes y efectos de los contaminantes más importantes, su control y métodos de análisis modernos

El aprovechamiento del libro de Fergusson será mucho mejor toda vez que el lector tenga ya bases elementales de Química General No pretende este volumen hacer un análisis exhaustivo en la materia sino más bien dar una visión muy general del problema mesológico de hoy, no desde la perspectiva puramente ecológica sino desde el punto de vista de la Química Inorgánica Sin bien el libro toca una gran gama de temas de manera general, profundiza en unos cuantos de mucho interés para el químico ambiental, por lo que se ve enriquecido, con relación a otras publicaciones similares en el campo, al incluir aspectos de geoquímica y biotoxicología no encontradas normalmente en textos de Química General y Ambiental

Concluyendo, el libro "Inorganic Chemistry and the Earth" debe formar parte de la bibliografía de acceso inmediato para los estudiosos e investigadores en ciencias ambientales, especialmente para quienes requieran de la aplicación de la Química como Ciencia cuantificadora de impactos ambientales antropogénicos

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