The germination of colanuts (*Cola nitida* Ventenant) Schott and Endlicher

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SUMMARY

Factors affecting colanut (*Cola nitida* Ventenant) Schott and Endlicher, germination have been investigated. The storage of colanuts enhances germination of the nuts. Within 8 weeks white colanuts germinated faster than red or pink nuts. Some varieties of *C. nitida* show superior germination characteristics than others. Although greening of stored colanuts stimulates early radicle emergence, subsequent plumule emergence was not affected by greening. Nut size did not affect germination. Potassium nitrate, sodium nitrite, hydroxylamine, ammonium chloride and potassium cyanide did not show any consistent effect on the germination of colanuts stored for 4 weeks.

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RÉSUMÉ

OSEI-BONSU, K. & AFRIFA, M. K.: *La germination du kola,* (Cola nitida *Ventenant*) *Schott et Endlicher.* Les facteurs de germination du kola ont été étudiés. La mise en stockage améliore le taux de germination du kola. Dans 8 semaines, les taux de germination des kola blancs étaient plus élevés que des rouges ou des roses. Il y'avait des variétés de *Cola nitida* qui ont de bonnes traits de germination que d'autres. Bien que la mise en stockage du kola stimule l'émergence précoce de la radicule, l'apparition de la plumule ulterieurement n'a pas été influencée. La taille du noix n'a pas influencée la germination. Le nitrate de potassium, le nitrite de sodium, l'hydroxylamine, le chlorure d'ammonique et le canide de potassium n'ont pas eu des effets important sur la germination de kola mise en stockage pour 4 semaines.

Introduction

Colanuts show extreme variability in their ability to germinate. This characteristic is attributable to varietal effect (Dublin, 1965; van Eijnatten, 1967; van Eijnatten & Quarcoo, 1968) and maturity of the nut (van Eijnatten & Quarcoo, 1968; van Eijnatten, 1964; Odegbaro & Ogutuga, 1967; Ashiru, 1969; Karikari, 1973). Other factors known to affect the germination of colanuts include nut size (Clay, 1964; Dublin, 1965; van Eijnatten & Quarcoo, 1968), mechanical pretreatments like removal of testa (Clay, 1964), splitting of the nuts (van Eijnatten & Quarcoo, 1968) and cutting of the nuts (van Eijnatten, 1964; Dublin, 1965; Brown & Afrifa, 1971). The stimulatory effects of kinetin, thiourea and thiourea dioxide on colanut germination were also investigated by Ashiru (1969) and of light by van Eijnatten (1967), van Eijnatten & Quarcoo (1968) and Ashiru (1969).

An appraisal of some of these findings on colanut germination was carried out in the present study with a view to determining the most suitable treatment under Ghanaian conditions.

Materials and methods

The study was carried out from 1973 to 1977 at the Cocoa Research Institute sub-station at Bunso. Except otherwise indicated, the medium used consisted of a 1:1 mixture of topsoil and river sand and the nuts were usually planted flat in germination trays measuring 60 cm × 37 cm × 15 cm. The trays were usually kept under 50 per cent shade in a nursery, and watering was carried out regularly. Nuts with 2 mm radicle protrusions and/or with the emergence of the plumule above soil surface were recorded as having germinated.

Experiment 1

Nut size and colour. Colanuts harvested from the Institute's plantations were stored for 23 days

in baskets lined with banana leaves and then separated into two colour groups, Red and White. The nuts within each colour group were graded into small, medium and large with 10 ± 2g, 16 ± 2g, and 28 ± 2g mean weights respectively. Twenty nuts per treatment were sown in a randomized block design with three replications.

Experiments 2 and 3

Nut size and storage. Two experiments were carried out. The nuts procured from the Institute's colanut plots were graded into three sizes, small (10-15 g), medium (16-20 g) and large (above 20 g) nuts.

In Experiment 2, four storage periods of nuts were investigated: fresh nuts and nuts stored for 2, 8 and 12 weeks after harvesting.

In Experiment 3, six storage periods were investigated: fresh nuts and nuts stored for 2, 4, 8, 12 and 16 weeks after harvesting.

Forty nuts were used per treatment in a factorial experiment with randomized block design with two and three replicates for Experiments 2 and 3 respectively.

Experiment 4

Greening and storage. Fresh nuts and nuts stored for 4 weeks were greened by exposure to sunlight for 7 days. The nuts were thinly wrapped in banana leaves to prevent drying.

Ungreened and greened colanuts of similar storage period were compared in a completely randomized block design with 50 nuts per treatment in six replicates.

Experiment 5

Varietal effect. The six cultivars of *C. nitida* from the Institute's plantations that were used and their sources are listed below:

Cultivar	*Source*	*No. of trees*
Oyoko White	BX 1, Tafo	8
Kumasi White	Plot 1, Bunso	84, 92, 109
Noyem White	Plot 2, Bunso	78
Kade Pink	Plot 1, Bunso	112, 125, 176
Kade Pink	Plot 2, Bunso	214
Kade Red	Plot 2, Bunso	94

In each cultivar, nuts collected from the trees were bulked together and stored for 21 days in baskets lined with banana leaves before being used for the germination test. The number of nuts used depended on the number available.

Experiment 6

Effect of chemical treatments. The effect of nitrite, nitrate azide, hydroxylamine, and ammonium salt on the germination of colanuts was tested. The chemicals were at five concentrations as listed below:

Chemical	*Concentration (ppm)*				
Potassium nitrate	0	2.0	5.0	10.0	15.0
Sodium nitrite	0	0.5	1.0	1.5	2.0
Hydroxylamine	0	0.1	0.3	0.5	0.7
Ammonium chloride	0	2.0	5.0	10.0	15.0
Potassium cyanide	0	0.5	0.10	0.15	0.20

All zero levels represent control treatments with distilled water. Forty nuts of medium size (15-20 g) stored for 4 weeks were weighed and soaked in 2 *l* of the appropriate chemical for 5 days. Final absorption of water was recorded by weight after the soaking and the nuts sown. Radicle and plumule emergence were recorded at 21 and 56 days after sowing respectively.

TABLE 1

The Effect of Nut Size and Colour on the Percentage Radicle Emergence of Colanuts (Arcsin transformed) (Experiment 1)

Size and colour of nuts	*Days after sowing*				
	21	28	35	45	55
Small white	46.9	51.2	54.8	60.9	65.9
Medium white	48.0	58.9	62.2	65.9	73.3
Large white	40.2	46.9	58.9	70.3	77.1
Small red	39.2	47.9	54.7	62.2	64.7
Medium red	34.9	51.8	54.9	65.5	66.8
Large red	**36.3**	**49.8**	**54.7**	**65.9**	**77.1**

Results

Nut size and colour

Significantly more white nuts than red nuts had germinated by day 21 ($P = 0.05$) but no differences were detected thereafter (Table 1). Final germination percentage appeared to be higher for the large nuts than for the small nuts, but nut size had no significant effect. There was also no interaction between nut size and colour.

Nut size and storage

Storage of the nuts had a significant effect ($P = 0.1$) on germination (Table 2). In Experiment 2 storage for up to 2 weeks did not affect germination but storage for 8 to 12 weeks greatly enhanced germination. There was no difference between the effect of 8 and 12 weeks storage on total germination. In Experiment 3, storage for 2 weeks was better than the fresh nuts. However, storage for 4 to 8 weeks resulted in even better germination than for 2 weeks (Table 2). Seed size did not have any effect on the germination of the nuts. There was also no significant interaction between seed size and storage.

Greening and storage

Greening of stored nuts recorded faster radicle emergence than when not greened (Table 3), and the effect was very significant only at 28 days after sowing ($P = 0.01$).

TABLE 2

Effect of Nut Size and Storage on the Germination of Colanuts (Arcsin transformed)

	Storage (weeks)	Percentage germination			
Experiment 2		*Small*	*Medium*	*Large*	*Mean*
	0	35.8	63.4	66.0	61.7b
	2	53.0	57.6	67.2	59.2b
	8	75.6	80.9	63.4	73.3a
	12	70.5	78.9	78.9	78.8a
	Mean	63.7	70.2	68.9	-
	LSD at 5 % = 6.9				
Experiment 3	0	35.7	40.2	42.1	38.7c
	2	52.7	55.7	55.7	54.7b
	4	75.0	65.9	70.0	70.3a
	8	56.8	59.5	64.0	60.1a
	12	70.8	73.2	77.1	73.7a
	16	70.8	70.8	68.6	70.1.a
	Mean	59.9	60.9	60.9	-
	LSD at 5 % = 12.2				

TABLE 3'

Effect of Greening and Storage on the Germination of Colanuts (Arcsin transformed) (Experiment 4)

Treatment	*% Radicle emergence 28 days after sowing*	*% Plumule emergence 56 days after sowing*
Stored ungreened	35.5	26.4
Stored greened	48.2	36.0
Fresh ungreened	40.1	29.1
Freshed greened	36.5	31.9
LSD at 5 %	5.9	9.2

Varietal effect

There was a highly significant difference ($P = 0.5$) in initial germination between Red and White nuts for up to 6 weeks after sowing (Table 4 a, b). White nuts tended to germinate faster than Red nuts, but there was no difference in their germination rates by week 8. Within the White nuts group, Oyoko White nuts consistently showed significantly faster germination ($P = 0.01$) than the Kumasi and Noyem nuts at 4, 6 and 8 weeks after sowing. There was no difference in the germination rate within the Red colanuts 6 weeks after sowing.

TABLE 4 a
Varietal Effect on Colanut Germination - Experiment 5

Variety	*Source*	*No. of nuts sown*	*% germination after 4*	*6*	*8 weeks*
Oyoko White	BX 1, Tafo	100	83	88	94
Kumasi White	Plot 1, Bunso	195	26	39	59
Noyem White	Plot 2, Bunso	80	32	74	88
Kade Pink	Plot 1, Bunso	130	40	41	82
Kade Pink	Plot 2, Bunso	80	57	57	88
Kade Red	Plot 2, Bunso	80	42	73	90

Effect of chemical treatment

Pre-treatment of colanuts with chemicals depressed water absorption (Table 5). In subsequent germination tests, radicle emergence after 21 days was also depressed by pre-treatment with ammonium chloride, sodium nitrite and hydroxylamine. The results suggest that higher concentration of potassium nitrate may increase radicle emergence. The other chemicals showed no clear pattern in the effect of increasing concentration on radicle emergence. Generally, plumule emergence was not affected by pre-treatment with any chemical.

TABLE 4b
Chi-squared Test of Varietal Effect on Colanut Germination

Weeks after sowing	*Between colour groups*	*Within colour groups*	
		White	*Red*
4	0.446 N.S.	53.64*	3.29*
6	6.272*	31.89*	0.93 N.S.
8	2.73 N.S.	12.56*	0.42 N.S.

* Significant at $P = 0.05$.

Discussion

That nut size does not have any effect on the germination of *C. nitida* nuts, confirms earlier findings by Clay (1964) and van Eijnatten (1968) but contrasts with Dublin (1965), Ibikunle & Mackenzie (1974) who reported a significantly poor germination from the smallest and largest nut sizes in *C. nitida.* The indication that White nuts tend to show faster radicle emergence than Red nuts in *C. nitida* has also been reported by van Eijnatten (1969).

The stimulatory effect of storage on germination found in this study and also recorded by van Eijnatten (1967, 1968, 1974), Clay (1964), Ashiru (1969) and Ibikunle & Mackenzie (1974) could either be due to the breakdown of inhibitory endogenous substances or to loss of water during the sweating of colanuts in storage. This could constitute the after-ripening requirement of colanuts prescribed by Karikari (1973). van Eijnatten (1974) also noticed that the embryos of stored *C. nitida* nuts were more developed morphologically than those of fresh nuts. This could be the result of embryo maturation in storage which sometimes causes the nuts to germinate even in storage (Oladokun, 1985).

Even though there was a synergistic effect of cotyledon greening on stored nuts in radicle emer-

TABLE 5

Effect of Some Chemicals on Water Absorption and Germination of Colanuts

Chemical	*Conc. (ppm)*	*H_2O absorbing (g/nut)*	*Radicle emergence (%)21 days after sowing*	*Plumule emergence (%) 56 days after sowing*
	0	2.00	39.3	51.3
	2	1.25	15.3	50.7
NH_4Cl	5	1.13	30.7	59.3
	10	1.13	23.3	45.3
	15	1.50	28.7	39.3
	0	2.00	36.0	49.3
	0.5	0.75	23.3	54.7
$NaNO_2$	1.0	1.00	26.7	57.0
	1.5	1.00	23.3	56.7
	2.0	0.75	26.0	56.7
	0	2.13	24.0	53.3
	2	1.00	16.0	46.7
KNO_3	5	1.00	21.3	52.0
	10	1.13	21.3	47.3
	15	1.25	30.7	47.0
	0	2.30	8.7	47.3
	0.05	1.50	9.3	63.3
KCN	0.10	0.88	17.3	51.3
	0.15	0.88	20.0	50.0
	0.20	1.25	14.7	46.0
	0	2.13	25.3	53.3
	0.1	1.13	17.3	46.0
$NH_2OH.HCl$	0.3	1.25	21.3	48.0
	0.5	1.25	19.3	66.7
	0.7	1.13	16.7	68.0

gence, greening did not influence plumule emergence as reported by van Eijnatten (1968). The fact that the nuts were continuously illuminated until the end of van Eijnatten's trial could account for the accelerated plumule emergence. In contrast, greening stopped when the nuts were planted at 5 cm below soil surface in the present study, thus confirming Ashiru's (1969) observation that any advantage in initial high root emergence from illumination is lost 30 days after sowing.

Variations in the rates of germination of colanuts have been attributed to the use of materials of different genetic origin (Dublin, 1965; van Eijnatten & Quarcoo, 1968). van Eijnatten (1967) reported that Gambari White colanuts germinated faster than Agege Red colanuts which had been stored for a longer period. The results of the present study in which White colanuts germinated faster than Red/Pink nuts confirm the above observations. Again within each colour group some cultivars were noted to show very rapid germination compared to those from other origins.

The use of KNO_3 for breaking seed dormancy is a common practice recommended by the International Seed Testing Association (1976). However, it is known that nitrate action in seed germination depends on the nitrite, hydroxylamine or nitric oxide derivatives of the nitrate ion (Hendricks & Taylorson, 1974). The inhibitory effects of these chemicals on germination of colanuts could probably have resulted from the limitation of water uptake by the nuts.

Ammonium salts inhibit germination of *Phleum pratense* seeds at 30 °C whilst hydroxylamine stimulated germination of seeds mostly at concentrations below 0.1 m*M* (Hendricks & Taylorson, 1974). The concentrations of hydroxylamine used were far stronger than recommended and that could account for the observed result. The findings for KNO_3 and $NaNO_2$ on colanuts sharply contrast with the putative effects in other seeds in which it is used to break dormancy (Ellis, Hong & Roberts, 1985); but it must also be noted that KNO_3 is not reputed to be a dormancy breaking agent for all types of seeds. Thus, it can be said that of the chemicals so far tested, only thiourea and kinetin (Ashiru, 1969; Odegbaro & Ogutuga, 1967) are suitable for breaking dormancy in colanuts.

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