

1 **Varietal response of Cola species to fertilizer application on field establishment, growth, development**
2 **and canopy characteristics**

3

4 Abstract

5 Responses of *Cola nitida* and *Cola acuminata* to NPK and Super-gro fertilizers on seedling development,
6 field establishment, and canopy characteristics were investigated in 2019-2020. Seedlings of the two
7 Cola species were transplanted as a randomized complete block design with three replications on the
8 field. Fertilizer treatments were imposed and the shoot and root growth parameters of the cola were
9 monitored for two growing seasons. From the results, application of NPK fertilizer positively enhanced
10 leaf and stem branch development as well as canopy features of the cola species compared to super-gro
11 and the control treatments. Seedling height and leaf area development were higher significantly
12 through application of super-gro compared with other treatments. Seedlings establishment were
13 enhances by the application of super-gro over NPK and the control plots. Leaf production, stem branch
14 number, stem girth development and leaf area development in *Cola nitida* were significantly higher than
15 in *Cola acuminata*. *Cola acuminata* seedlings height were significantly higher compare to Cola nitida
16 during the two growing seasons. The interactions of fertilizers and crop species reveals that NPK and
17 super-gro application significantly influenced leaf production in C acuminata over C nitida. Stem branch
18 production in C acuminata was better significantly under the treatment of NPK than that of C nitida
19 under super-gro and the control plots. Canopy development was significantly higher under Cola
20 acuminata treated with Super-gro followed by NPK with the control having the least. Canopy
21 development in Cola nitida were significantly lower compared with Cola acuminata across the fertilizer
22 treatments.

23 **Key words:** Cola, Development, Establishment, Fertilizer, growth, variety

24 **Introduction**

25 Colanut (*Cola spp. L*) is the fruit of the Cola trees that are from the tropical rainforests of Africa
26 and a member of the family *Malvaceae* (formerly *sterculiaceae*). It is an important cash crop to a
27 significant proportion of Nigerian population who are involved in Colanut farming, trading and
28 industrial utilization. Almost 50 Cola species have been identified in West Africa, however, the
29 Cola species of economic importance in Nigeria are *Cola nitida* and *Cola acuminata* (Atanda *et*
30 *al.*, 2011). Colanut has world production of 300,000 metric tonnes, however, Nigeria accounts
31 for (88%) of the total world production of Colanuts (Quarco, 1973 and Oladokun, 2000). It is
32 cultivated to a large degree in Southern part of Nigeria, Ghana, Ivory Coast, **Cameroon**, Sierra
33 Leone, Brazil and the West Indian Islands (FAOSTAT, 2015).

34 Colanut production in Nigeria is limited by a number of problems ranging from low yield, pest,
35 diseases, low soil fertility and pronounced dormancy (Hammed *et al.*, 2018). Other factors
36 contributing to reduction in the cultivation of the crop is the stress involved in the establishment
37 of the plantation through seeds, due to pronounced dormancy that persist up to 8-months thereby
38 reducing the rate of germination, emergence and subsequent slow growth and development
39 which makes plantation establishment cumbersome (Famade, 2012, Hammed *et al.*, 2013). The
40 available trees are of age, some are dying due to fire hazard coupled with increase human
41 population which has led to reduction in number of Cola trees.

42 Despite the uses and economic importance of the crop, it has not received the needed attention in
43 the area of plantation establishment among others as a result of over exploitation. Cola is
44 extinction-threatened in several west and central African countries such as Ivory Coast, Togo,
45 Congo and Sierra Leone (Eyog-matig *et al.*, 2017). Another factor threatening the survival of the
46 Cola is its poor natural regeneration and slow growing seedlings (Abbiw, 1990; Gyimah, 2014).

47 Today, it is very difficult to find plantation of Colanut in Nigeria due to difficulties associated
48 with its propagation, establishment, post-nursery performance and products marketability
49 (Gyimah, 2000; Kammengne and Ndoumou, 2017; Oboho and Urugbu, 2010; Oboho and Ogana,
50 2011; Yakubu *et al.*, 2014).

51 Application of soil amendments like NPK fertilizer and Super-gro have been researched to
52 enhanced crop growth and establishment on the field for annual crops but much have not being
53 done on their effects on plantation crops (Cola, Rubber and Cocoa) establishment and
54 development. Super-gro is a 100% organic liquid fertilizer which is made from poultry droppings
55 and sea bird guano, it is eco-friendly and made from organic matter with absolutely no chemicals
56 added to it. While, NPK fertilizer is a synthetic compound fertilizer applied to the soil or to plant
57 tissues to supply basic plants nutrients essential for the growth of plants.

58 The research work aimed at investigating the effects of fertilizers on field establishment, growth,
59 development and canopy characteristics of two Cola species.

60

61 **MATERIALS AND METHODS**

62 The research was carried out at the Teaching and Research Farm of the Federal University of
63 Technology, Akure (FUTA), FUTA is located on altitude of 332 m above sea level, 7 16'N,
64 512'E longitude and latitude in rainforest zone south-western Nigeria. The experiments were
65 conducted during the growing seasons of 2019 to 2021. Pods of two species of Cola were
66 obtained from Cocoa Research Institute of Nigeria (CRIN) Oyo State, Nigeria. The seeds were
67 raised through the nursery to seedlings using standard agronomic procedures for nursery
68 production.

69 **Effects of fertilizers on growth, development and field establishment of Cola species**

70 The experiment was conducted between May 2019 to December 2021 to investigate the effects
71 of NPK and super-gro on growth, development and establishment of Cola species on the field.

72 The sites were manually cleared and laid out at the Teaching and Research Farm of Federal
73 University of Technology, Akure. The raised seedlings were transplanted at a spacing of 7m x
74 7m with six plant per sub plot and a total population of 108 Cola stands .

75 **Experimental design, treatment and planting**

76 2 x 3 Factorial experiment replicated three times, laid out in a Randomized Complete Block
77 Design (RCBD). Weeding and other agronomic practices were carried out as required. Manual
78 watering was carried out to supplement soil moisture deficit during the dry season.

79 Treatments application: NPK fertilizer 15-15-15 and super-gro were applied at one and four
80 months after transplanting at 4g/stand per application period for NPK and 1ml of super-gro to
81 one litre of water/plant applied as both folia and fertigation.

82 Data were measured on a two weeks interval on Number of leaves, Plant height, Stem girth (cm),
83 Number of branches and Leaf area development (cm²)

84 **Data analysis**

85 Data collected were subjected to statistical analysis (ANOVA) using Minitab 17 and the means
86 were separated using Tukeys test at 5% level of probability

87 **Results**

88 Effects of fertilizer treatments were examined on shoot and root development in the two cola
89 species. From the results shown in table 1, plant height was significantly higher in super-gro
90 treated cola plots compared with NPK and control treated plots at 12 - 40 and 48 Weeks after
91 Sowing (WAS). Super-gro treated plot had superior plant height development when compared to
92 NPK and control treated plots.

93 Table 2 shows the effects of fertilizer on number of branches developed by the Cola species.

94 Application of NPK fertilizer significantly enhanced number of branches of young Cola plants
95 on the field. There were significant differences between NPK treated plots over super-gro and
96 the control. At 12 - 20 WAS, there were no significant differences in the number of branches
97 between NPK, super-gro and control plots. At 24 - 40 WAS and 72 WAS, similar number of
98 branches were produced by NPK and super-gro treated plots and were significantly higher than
99 the control plots. At 44 - 68 WAS, significantly higher number of branches were produced by the
100 NPK treated plots compared with super-gro and the control plots. More branches were produced
101 by the NPK treated plots than the super-gro and control plot.

102 Table 3 shows the effects of fertilizers on stem girth development of two species of Cola. At 12
103 WAT (Weeks after Transplanting), seedlings grown on NPK treated and unfertilized plots
104 produced similar stem girth which was significantly thicker in girth over recordings on plants
105 grown on super-gro treated plots. At 16-44 WAT, 68 and 72 WAT, similar stem girth was
106 produced by seedlings grown on NPK, super-gro as unfertilized control plots. At 48-52 WAT,
107 60-64 WAT, seedlings grown on plots treated with super-gro and unfertilized control had similar
108 stem girth which was significantly thinner. At 56 and 68 WAT significantly thicker stem girth
109 was observed on seedlings raised in super-gro and NPK treated plots.

110
111 Table 5 shows the effects of NPK fertilizer and super-gro on leaf area of two Cola species.

112 At 12-72 WAT, significantly wider leaf area was produced by seedlings grown on super-gro
113 treated plots with exception of 12 WAT, 44-48 WAT and 56 WAT, seedling grown on NPK
114 treated and the unfertilized plots produced similar leaf area. Wider leaf was observed with the
115 seedlings grown on super-gro treated plots while seedlings grown on NPK treated and control
116 plots produced similar leaf area.

117 Table 6 shows the effects of species on the number of leaves produced on the field.

118 From the Table, there were significant differences between *C. nitida* and *C. acuminata* in term of
119 number of leaves produced. *C. nitida* produced significantly higher number of leaves throughout
120 the periods of sampling except at 16 WAT when the number of leaves produced by *C. nitida* was
121 the same with *C. acuminata*.

122 Table 7 shows the effects of species on plant height on the field.

123 There was significant difference between *C. acuminata* and *C. nitida* in terms of plant height. *C.*
124 *acuminata* produced significantly higher plant height compared with *C. nitida* throughout the
125 period of the experiment excepting at 16-32 WAT where plant height of *C. acuminata* was the
126 same with *Cola nitida*.

127 Table 8 shows the effects of species on the number of branches produced on the field.

128 From the result, there were significant difference between *C. nitida* and *C. acuminata* in terms of
129 number of branches produced. However, the pattern of growth in the production of leaves as
130 influenced by the two Cola species was reflected in the production of number of branches. More
131 branches were produced by *C. nitida*.

132

133 Table 9 shows the effects of species on stem girth of *Cola nitida* and *Cola acuminata* on the
134 field.

135 From the result, there were significant difference between *C. nitida* and *C. acuminata* in terms of
136 stem girth development on the field. *C. nitida* produced similar stem girth with *C. acuminata*.

137 At 16-56 WAT, significantly thicker stem girth was produced by *C. nitida*.

138 Table 10 shows the effects of species on leaf area development of *Cola nitida* and *Cola*
139 *acuminata*

140 There was significant difference between *C. nitida* and *C. acuminata* in terms of leaf area
141 developments on the field. *C. nitida* produced significantly wider leaf area on the field compared
142 with *C. acuminata* throughout the period of the experiment excepting at 16 and 28 WAT when
143 the two species produced similar leaf area. *C. nitida* produced more branches, leaves and
144 ultimately wider leaf area.

145 Table 11 shows the combined effects of species and fertilizers on number of leaves produced.

146 From the results, combination of NPK fertilizer significantly influenced leaf production of *Cola*
147 *acuminata* compare to other combination of fertilizers and species. At 12, 16 and 20 weeks after
148 transplanting, no significant difference between combination of NPK and *C. acuminata*
149 compared with super-gro and *C. nitida*. Beginning from week 24 to 72, NPK was significantly
150 higher in both *C. acuminata* and *C. nitida* compare with super-gro and control. In *C. nitida*
151 super-gro was relatively higher than NPK fertilizer. Significantly higher number of leaves was
152 produced by *C. acuminata* grown on NPK treated plots in all sampling periods excepting at
153 12WAT where the number of leaves produced by *C. acuminata* on NPK plots was similar with
154 super-gro treated plots.

155 *C. acuminata* grown on plots treated with super-gro produced more leaves which was only
156 significant at 12, 16 and 20WAT, similar number of leaves was produced by *C. acuminata* on
157 super-gro and NPK treated plots.

158
159 Table 12 shows the combined effects of species and fertilizers on plant height.

160 From the results super-gro significantly influenced plant heights development of *Cola acuminata*
161 compared to other treatment combinations. In *Cola nitida*, NPK fertilizer significantly influenced
162 plant heights compare to other treatment combinations. From 12 weeks after transplanting, there

163 were significant differences between combination of super-gro and *C. acuminata* compared with
164 NPK and *Cola nitida*. Interaction between super-gro and *Cola acuminata* was significantly
165 higher compared with super-gro and *Cola nitida*. Hence, super-gro applied to the plants
166 influenced the plant height development on the field.

167 Table 13 shows the combine effects of species and fertilizers on number of branches.

168 From the results, NPK fertilizers significantly influenced branch production in *Cola acuminata*
169 compared to other combinations. No significant differences between combination of NPK and *C.*
170 *acuminata* compared with super-gro and *C. nitida* species at 12, 16, 20 weeks after transplanting.
171 At 44 weeks after transplanting NPK performed higher than super-gro and the control in term of
172 stem branch development.

173 Table 14 shows the combine effects of species and fertilizers on stem girth produced.

174 From the results, combinations of NPK fertilizers with *Cola acuminata* significantly influenced
175 the stem girth development compared with the combination NPK and *C. nitida* and Super-gro
176 and *C nitida*..

177 Table 15 shows combined effects of *Cola* species and fertilizers on leaf area development on the
178 field. From the results, NPK fertilizers significantly influenced the leaf area production of *Cola*
179 *acuminata* and *Cola nitida* over Super-gro on the two species. Likewise, in *Cola nitida* NPK
180 fertilizer produced more leaf area between week 12, to 72 after sowing compared to super-gro
181 and control.

182 **Discussion**

183 Optimum crop performance is greatly determined by availability of essential nutrients at the right
184 rate, right time and right proportion according to Agele et al., 2011. The results of the
185 experiments highlighted the superiority of fertilized plants over non-fertilized in term of growth
186 and development in two Cola species. The consistent poor performance of non-fertilized plant
187 shows that when nutrients are inadequate, Cola plant do not grow well and develop properly.
188 Application of fertilizers (Super-gro and NPK) had positive influence on the growth,
189 development and field establishment of the two Cola species as evident in the results.

190 **Effects of Cola species and fertilizers on growth and development and field establishment of** 191 **Colanut**

192 Effects of fertilizers application on the two Colanut species significantly increased the number of
193 leaves produced. This was attributed to the availability of essential nutrients for shoot growth
194 and development during active growth stage of the plant. The findings was in tandem with that
195 of Famuwagun and Oladitan, (2020) that application of NPK fertilizer led to increased leaf
196 production in cocoa seedlings. The number of leaves in *Cola acuminata* were significantly
197 higher than that of *Cola nitida*. Super-gro and NPK fertilizer produced more number of leaves in
198 *C. acuminata* compared to *C. nitida*. The positive influence of super-gro on vegetative
199 development in arable and perennial crops was reported by Alaneme and Howells, (2022) that
200 application of super-gro aided increased leaf production on field grown fluted pumpkin. Also,
201 Ayeni, (2008) reported the use of both organic and inorganic fertilizer for enhanced growth and
202 development of crops.

203 **Effect of species and fertilizers on plant height.**

204 Transplanted seedlings of *C. acuminata* showed better response to fertilizers than seedlings of
205 *Cola nitida* in the plant height development, leaf production rate and leaf area development.
206 These findings may be due to genetic traits as reported by Opeke, 2005 that trees of *C.*
207 *acuminata* are taller and bigger than *C. nitida* that are of the same age and in same location. *C.*
208 *acuminata* seedlings were taller compared to that of *C. nitida* under NPK and Super-gro
209 treatment over the control. Agele *et al.*, (2011) observed similar increase in growth parameters in
210 tomato and pepper under NPK fertilizer application.

211 The highest number of branches were obtained from *C. acuminata* treated with NPK fertilizer
212 followed by Super-gro application. *Cola acuminata* produced more number of branches
213 compared to *C. nitida*. These may be traced to availability of nutrient in the soil for assimilate
214 production towards growth and development as well as the genetic makeup of the variety that
215 usually produced more stem branch. This was supported by Babalola *et al.*, 2002 and Opeke,
216 2005 that *C. acuminata* are more vigorous than *C. nitida*.

217 The leaf area of *Cola nitida* was relatively higher than those obtained in *Cola acuminata* during
218 the two seasons of the experiment. NPK fertilizer had a significantly higher impact on the leaf
219 area development than Super-Gro in *Cola nitida*. The increased leaf area development of the
220 two *Cola* species with NPK and super-gro application implied timely and sufficient supply of
221 required nutrients which in turn enhanced photosynthetic activities for growth and development.
222 These findings was in tandem with that of Famuwagun and Oladitan (2020) that application of
223 NPK fertilizer enhanced leaf area development in cacao.

224 Application of NPK fertilizer and super-gro aid quick establishment of *Cola*. It increases the soil
225 nutrient that brought about rapid growth and development of *Cola* species.

226 The super-gro provide enabling environment for leaf formation and development which increase
227 the photosynthetic activity of the leaves that enhances the rapid growth of the Cola.

228 **Conclusion**

229 Based on the findings of the research, it was concluded that fertilizer application in cola spp
230 plantation establishment is a major booster of vegetative growth and development.

231 It was also concluded that the use of super-gro and NPK 15-15-15 fertilizer enhances quick
232 plantation establishment in cola.

233 **Recommendation**

234 Based on the result of this study, the following were recommended;

235 Application of NPK fertilizer and Super-gro is recommended for quick field establishment.

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