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

Abstract

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

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

Introduction

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

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

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

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

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

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

MATERIALS AND METHODS

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

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

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

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

Experimental design, treatment and planting

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

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

Data were measured on a two weeks interval on Number of leaves, Plant height, Stem girth (cm), Number of branches and Leaf area developemt (cm^2)

Data analysis

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

Results

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

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

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

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

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

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

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

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

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

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

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

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

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

From the result, there were significant difference between *C. nitida* and *C. acuminata* in terms of stem girth development on the field. *C. nitida* produced similar stem girth with *C. acuminata*. At 16-56 WAT, significantly thicker stem girth was produced by *C. nitida*.

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

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

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

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

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

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

From the results super-gro significantly influenced plant heights development of *Cola acuminata* compared to other treatment combinations. In *Cola nitida,* NPK fertilizer significantly influenced plant heights compare to other treatment combinations. From 12 weeks after transplanting, there were significant differences between combination of super-gro and *C. acuminata* compared with NPK and *Cola nitida*. Interaction between super-gro and *Cola acuminata* was significantly higher compared with super-gro and *Cola nitida*. Hence, super-gro applied to the plants influenced the plant height development on the field.

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

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

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

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

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

Discussion

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

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

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

Effect of species and fertilizers on plant height.

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

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

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

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

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

Recommendation

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

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

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Table 1: Effects of NPK fertilizer and super-gro application on Cola species on number of leaves of two species of Cola.

Fertilizer	Weeks after transplanting.															
	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72
Super-gro	12.5a	15.00 a	17.25 a	18.00 b	20.00 b	26.88 b	28.13 b	28.13 b	25.38 c	28.75 c	36.50 c	34.38 c	32.04 c	30.02 c	28.01 c	27.04 c
NPK	10.88 a	14.63 a	19.87 a	27.50 a	30.50 a	49.13 a	53.38 a	59.88 a	61.50 a	62.00 a	64.3a	65.50 a	63.02 a	61.01 a	58.03 a	56.02 a
Control	7.88b	12.00	17.13	18.13	26.38	26.13	32.13	31.75	33.63	41.50	47.00	48.75	44.25	41.20	39.02	37.01

Means in same column followed by same letter (s) are not significantly different @ p ≤0.05.

Table 2: Effects of NPK fertilizer and super-gro application on Cola species on plant height (cm) of two species of Cola.

Fertilizer	Weeks after transplanting (WAT)															
	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72
Super-gro	20.63 a	28.91 a	33.88 a	39.25 a	45.75 a	50.13 a	54.63 a	62.38 a	68.63 a	73.75 a	77.63 a	83.38 a	85.00 a	88.04 a	90.12 a	94.04 a
NPK	10.38 b	26.43 a	32.46 a	35.54 a	41.33 a	48.25 a	54.50 a	57.50 b	63.75 a	69.38 b	75.88 a	81.88 a	82.30 a	85.01 a	88.05 a	90.22 a
Control	8.00b	21.63	23.29	25.19	27.50	37.63	37.63	42.25	50.25	53.00	55.63	60.63	61.80	63.00	65.08	67.00

Means in same column followed by same letter (s) are not significantly different @ p ≤0.05.

Table 3: Effects of NPK fertilizer and super-gro application on the number of branches of two species of Cola.

Fertilizer	Weeks after sowing															
	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72
Super-gro	1.88a	2.25a	2.50a	2.50a	2.50ab	3.00ab	3.50a	3.50ab	3.75b	4.00b	4.13b	4.58b	4.88b	5.20b	5.35b	5.48a
NPK	1.88a	1.88a	2.38a	2.75a	3.13a	3.88a	4.50a	5.00a	6.25a	6.38a	6.75a	8.18a	8.38a	8.58a	8.67a	8.72a
Control	1.00a	1.38a	1.38a	1.75b	1.75b	1.75b	1.88b	2.00b	2.25b	2.88b	3.38b	4.00b	4.38c	4.58c	5.00b	5.10b

Means in same column followed by same letter (s) are not significantly different @ p ≤0.05

Table 4: Effects of NPK fertilizer and super-gro application on Cola spp. on stem girth of two species of Cola

Fertilizer	**Weeks after transplanting**															
	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72
Super-gro	1.38b	1.76a	2.14a	2.44a	2.54a	2.81a	2.96a	3.18a	3.34a	3.53b	3.80b	4.12a	4.54b	4.60b	4.70a	4.90a
NPK	1.65a	2.03a	2.33a	2.53a	2.71a	3.04a	3.20a	3.48a	3.69a	4.15a	4.33a	4.78a	4.90a	5.10a	5.20a	5.35a
Control	1.66a	1.95a	2.28a	2.29a	2.61a	2.98a	3.06a	3.24a	3.55a	3.53b	3.79b	3.89b	4.10b	4.30b	4.50b	4.60a

Means in same column followed by same letter (s) are not significantly different @ p ≤0.05.

Table 5: Effects of NPK fertilizer and super-gro application on leaf area (cm) of two species of Cola.

Fertilizer	Weeks after transplanting (WAT)															
	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72
Super-gro	137a	213a	220a	220a	230a	234a	235a	240a	248a	250a	253a	260a	234a	220a	214a	211a
NPK	79.45b	136b	140b	142b	145b	148b	155b	165b	185b	210b	217b	235b	220b	215b	210b	205b
Control	52.24c	130b	140b	142b	145b	148b	155b	165b	171c	190c	210b	217c	213b	210b	206b	204b

Means in same column followed by same letter (s) are not significantly different @ p ≤0.05.

Table 6: Effects of Colanut species on number of leaves

Species	Weeks after transplanting														
	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72
C. nitida	14.50 a	29.60 a	32.40 a	39.80 a	41.40 a	42.40 a	50.60 a	54.20 a	63.10 a	65.00 a	67.00 a	70.10 a	75.10 a	69.00 a	66.00 a
C. acuminata	18.60 a	19.50 b	22.40 b	26.50 b	26.90 b	28.10 b	28.01 b	30.10 b	32.40 b	36.00 b	36.50 b	37.10 b	39.20 b	36.80 b	34.40 b

Means in same column followed by same letter (s) are not significantly different @ p ≤0.05.

Table 7: Effects of Cola species on plant height development (cm)

Species	Weeks after transplanting (WAT)														
	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72
C. nitida	10.80 a	14.20 a	14.40 a	16.80 a	16.90 a	20.20 b	27.50 b	32.00 b	33.50 b	44.20 b	49.50 b	52.60 b	56.20 b	58.00 b	60.10 b
C. acuminata	15.50 a	17.50 a	19.20 a	24.30 a	29.10 a	33.40 a	39.10 a	40.20 a	48.60 a	56.80 a	63.20 a	69.60 a	71.30 a	73.50 a	75.00 a

Means in same column followed by same letter (s) are not significantly different @ p≤0.05

Table 8: Effects of Cola species on number of branches

Species	Weeks after transplanting														
	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72
C. nitida	1.60a	1.80a	2.20a	2.40a	2.60a	3.40a	3.90a	4.30a	5.40a	6.10a	6.50a	7.20a	8.10a	8.50a	9.00a
C. acuminata	1.20a	1.60b	1.60b	1.70b	1.90b	2.30b	2.40b	2.60b	3.00b	3.20b	3.20b	3.50b	3.70b	4.00b	4.40b

Means in same column followed by same letter (s) are not significantly different @ $p \leq 0.05$.

Table 9: Effects of species on stem girth of *Cola nitida* and *Cola acuminata* on the field

Species	Weeks after transplanting (WAT)														
	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72
C. nitida	1.60a	1.65a	1.66a	1.69a	1.80a	2.00a	2.10a	2.30a	2.30a	2.70a	3.40a	4.20a	4.35a	4.70a	5.00a
C. acuminata	1.45a	1.60a	1.60a	1.65a	1.70a	1.89a	1.90a	2.10a	2.20a	2.40a	2.90a	3.00b	3.20b	3.40b	3.70b

Means in same column followed by same letter (s) are not significantly different @ p ≤0.05.

Table 10: Effects of Colanut species on leaf area of *Cola nitida* and *Cola acuminata* on the field

Species	Weeks after transplanting (WAT)														
	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72
C. nitida	119.80a	130.60a	136.40a	139.10a	152.00a	160.10a	164.20a	167.20a	168.00a	171.40a	173.20a	161.00a	159.20a	155.00a	179.00a
C. acuminata	111.90b	124.10b	128.60b	137.20b	143.50b	149.20b	152.40b	154.70b	156.00b	162.70b	166.50b	157.10b	152.20b	150.60b	167.00b

Means in same column followed by same letter (s) are not significantly different @ p ≤0.05.

Table 11: Combine Effects of Cola species and fertilizers on leaf production on the field

Species	Fertilizer	Weeks after transplanting (WAT)															
		12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72
C. acuminata	Supergro	10.25b	11.75b	12.50c	12.50c	15.25d	22.75c	20.75d	18.50d	17.00d	18.75d	33.00c	11.25d	16.50d	18.20e	22.40d	24.20d
	NPK	14.75a	18.50a	23.75a	32.50a	41.00a	70.75a	75.75a	85.00a	77.50a	82.25a	127.25a	58.75a	73.60a	75.60a	78.90a	80.02a
	Control	7.75c	9.50b	13.75c	14.00c	22.75b	17.25d	18.75d	16.75d	21.25d	19.00d	27.00d	36.25c	40.00c	45.10d	48.20c	50.00c
C. nitida	Supergro	12.75a	18.25a	22.00a	23.50b	24.75b	31.00b	35.50c	37.75c	33.75c	38.75c	40.00c	57.50a	58.10b	62.10b	64.10b	66.10b
	NPK	7.00b	10.75b	16.00b	23.50b	20.00c	27.50c	31.00c	34.75c	45.50b	38.75c	77.25b	52.25b	56.10b	48.40c	60.00b	62.20b
	Control	8.00b	9.50b	20.50a	22.25b	30.00b	35.00b	45.50b	46.75b	46.00b	64.00b	67.00b	35.25c	40.20c	45.80d	48.00c	50.00c

Means in same column followed by same letter (s) are not significantly different @ p ≤0.05.

Table 12: Combine effects of species and fertilizers on plant height

Species	Fertilizer	Weeks after transplanting (WAT)															
		12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72
C. acuminata	Super gro	28.50a	28.50a	42.75a	48.25a	56.00a	58.50a	65.00a	69.25a	76.75a	80.00a	87.25a	91.00a	94.60a	96.00a	97.08a	99.00a
	NPK	17.00b	28.98b	35.80b	37.08b	43.00b	51.50b	60.75a	61.50b	64.75b	69.00b	70.25b	80.50b	83.50b	85.02b	87.05b	88.09b
	Control	7.75d	24.75c	25.83c	28.75c	31.75c	46.75c	40.00c	47.25c	55.25c	60.00c	61.50c	71.25c	74.20c	76.00c	78.03c	81.08b
C. nitida	Super gro	12.75c	23.25c	25.00c	30.25c	33.50c	41.75c	44.25b	55.50b	60.50b	67.50b	68.00b	75.75c	77.13c	79.20c	82.00b	85.04b
	NPK	3.75e	23.93c	29.13c	34.00b	39.65b	45.00c	48.25b	53.50b	62.75b	69.75b	81.50a	83.25b	85.55a	87.23b	90.04a	92.08a
	Control	8.25d	18.50d	20.75c	21.63d	23.65d	28.50d	34.25d	37.25d	45.25d	45.50d	49.75d	50.00d	52.10d	54.00d	57.03d	59.04c

Means in same column followed by same letter (s) are not significantly different @ p ≤0.05.

Table 13: Combined effects of Cola species and fertilizers on number of branches produced

Species	Fertilizer	Weeks after transplanting (WAT)															
		12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72
C. acuminata	Super gro	2.25a	2.50a	2.50a	2.50b	2.50b	2.75c	2.75c	2.75d	3.00d	3.00d	3.00d	3.25d	3.75d	3.95d	4.02e	4.25e
	NPK	2.75a	2.75a	3.00a	3.75a	3.75a	5.00a	6.00a	6.50a	7.00a	7.00a	7.25a	7.75a	8.00a	8.05a	8.25a	8.50a
	Control	1.00b	1.75c	1.75c	2.50b	2.50b	2.50c	2.50c	2.75d	3.25d	3.25d	4.00d	4.00d	4.25d	4.50d	5.00d	5.25d
C. nitida	Super gro	1.50b	2.00a	2.50b	2.50b	2.50b	3.25b	4.25b	4.25b	4.50c	5.00b	5.25c	5.25c	5.75c	6.00c	6.25c	6.50c
	NPK	1.00d	1.00d	1.75c	1.75c	2.50b	2.75c	3.00c	3.50c	5.50b	5.75b	6.25b	6.25b	6.80b	7.00b	7.25b	7.50b
	Control	1.00d	1.00d	1.00d	1.00d	1.00d	1.00d	1.25d	1.25d	1.50e	2.50e	2.75e	2.75e	2.85e	3.00e	3.25f	3.50f

Means in same column followed by same letter (s) are not significantly different @ p ≤0.05.

Table 14: Combined effects of Cola species and fertilizers on stem girth (cm) produced

Species	Fertilizer	Weeks after transplanting (WAT)															
		12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72
C. acuminata	Super gro	1.18c	1.58b	2.15b	2.54b	2.54b	2.65d	2.70b	2.85b	2.85b	2.95d	3.18c	3.20c	3.35c	3.50c	4.10b	4.25b
	NPK	1.60a	2.10a	2.45a	2.61a	2.67a	3.08a	3.18a	3.36a	3.58a	3.97b	4.05b	4.39b	4.46b	4.50b	5.10a	5.25a
	Control	1.70a	2.03a	2.43a	2.65a	2.93a	3.23a	3.40a	3.58a	3.63a	3.98b	4.33a	3.25c	3.45c	3.50c	3.58c	4.10b
C. nitida	Super gro	1.58b	1.95a	2.13b	2.43a	2.55b	2.98b	3.23a	3.50a	3.83a	4.10a	4.43a	5.03a	5.09a	5.16a	5.20a	5.30a
	NPK	1.73a	1.98a	2.23b	2.43a	2.75a	2.95b	3.18a	3.50a	3.70a	4.25a	4.50a	5.05a	5.15a	5.25a	5.45a	5.55a
	Control	1.63a	1.88a	2.13b	1.93c	2.30c	2.73c	2.73c	2.90a	3.08a	3.08b	3.25c	3.43c	3.50c	3.55c	3.63c	3.70c

Means in same column followed by same letter (s) are not significantly different @ p ≤0.05.

Table 15: Combined effects of species and fertilizers on leaf area (cm) development on the field

Species	Fertilizer	Weeks after transplanting (WAT)															
		12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72
C. acuminata	Super gro	48.90e	177.80c	210.85b	207.1b	217.10b	224.80b	233.70c	237.23c	247.88b	248.08b	232.18c	228.93c	226.09c	220.01c	217.02c	214.02c

	NPK	188.60a	324.75a	222.75b	226.00a	206.25b	181.65d	280.75a	236.70b	190.55c	249.50b	240.25b	108.25d	106.01d	102.05d	100.01d	97.03d
	Control	38.05f	132.03d	122.50d	79.50e	91.00d	58.54f	71.00e	152.85c	124.76e	134.65c	134.65d	103.75e	101.67d	99.02e	97.01d	95.03d
C. nitida	Super gro	85.45c	241.25b	246.50a	217.00a	206.25b	260.98a	298.25a	230.60b	245.65b	246.10b	240.25b	287.25b	275.02b	272.01b	268.00b	250.00b
	NPK	120.85b	252.43b	147.25c	183.00c	195.50c	215.86c	258.50b	309.50a	337.75a	357.75a	334.65a	357.25a	350.00a	345.08a	338.02a	332.00a
	Control	55.58d	94.20d	106.00e	96.58d	94.58d	88.97e	107.25d	99.13d	155.58d	116.90d	232.18c	71.68f	69.00f	66.01f	65.02e	62.01e

Means in same column followed by same letter (s) are not significantly different @ p ≤0.05