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Assessment of aqueous leaf extract of false rubber tree (*Holarrhena floribunda*) on vegetative growth of three varieties of cocoa seedlings

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Abstract

The recent challenge facing the optimum production of cocoa in Nigeria is the scarcity of rich topsoil for nursery production which often leads to poor growth and development of cocoa trees. This study therefore, assessed the effect of aqueous leaf extract of *Holarrhena floribunda* (G.) on the vegetative growth of three varieties of cocoa seedlings. The experiment was conducted within the Nursery Section of Cocoa Research Institute of Nigeria, Ibadan. Completely Randomized Design (CRD) was adopted with seven treatments using varied concentrations of *Holarrhena floribunda* (*H. floribunda*) at 10, 5, 3.33 and 2.5%; Supergro, CocoBoost and control. The three cocoa varieties planted were CRIN TC1, V1; CRIN TC3, V2; and F3 Amazon, V3. Treatments were directly sprayed on the leaves of cocoa seedlings at two weeks interval starting from fourth week after seeds sprouting for 16 weeks. Data were collected at two weeks interval for sixteen weeks on numbers of leaf, plant height, stem girth and leaf area. Two way analysis of variance (ANOVA) was used to analyze the collected data at 5% level of significance. The result showed that Treatment 1 (10% concentration of *H. floribunda*) significantly ($p<0.05$) enhanced the vegetative growth of the three varieties of cocoa seedlings, especially on the number of leaves (16.11) and stem girth (0.98 cm). The outcome of the study showed that aqueous leaf extract of *H. floribunda* possesses plant macro and micro nutrients which makes it a potential plant growth enhancer for cocoa seedlings (Potassium (K) 0.70%, Calcium (Ca) 1.31%, Magnesium (Mg) 1.12%, Sodium (Na) 0.15%, Organic carbon (C) 46.0%, Nitrogen (N) 3.61%, Manganese (Mn) 0.003%, Iron (Fe) 0.07%, Copper (Cu) 0.003%,Phosporus (P) 0.10% and Zinc (Zn) 0.007%). The study recommended that aqueous leaf extract of *H. floribunda* be adopted as a plant growth enhancer for cocoa seedlings at nursery stage.

Keywords: Cocoa varieties, *Holarrhena floribunda*, Leaf extract, Vegetative growth

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Introduction

Theobroma cacao L. of the family Malvaceae is one of the major cash crops due to the economic importance derived especially from its beans which attract huge income in the World market (Osarenren & Emokaro, 2015). This economic tree is cultivated widely throughout the world especially in countries such as Cote d'Ivoire, Ghana, Indonesia, Nigeria, Cameroon, Brazil and so on (World Cocoa Foundation, 2014). The varieties cultivated in the olden times such as Forestario, Criollo and Trinitario are with attendant problems including late maturity, low yield, susceptibility to pests and diseases, susceptibility to drought amongst others (Swedish International Agricultural Initiatives, 2013). But in the recent time, Cocoa Research Institute of Nigeria released about eight varieties which are high yielding, resistant to pest and diseases, drought resistant and early maturing (Cocoa Research Institute of Nigeria, 2011).

One of the recent challenges facing the optimum production of cocoa in Nigeria is the non-availability of quality and quantity topsoil for nursery practices which is a very crucial stage of morphological development of cocoa plant (Nazeer et al., 2020). This often leads to poor growth and development of this important economic tree. There is need therefore to find a way to ameliorate this ugly situation by sourcing for alternative means through which the growth of cocoa seedlings could be enhanced right from the nursery stage in order to enhance field establishment and further boost cocoa production in Nigeria. The prospect of cacao tree is pre-determined by how seedlings are raised from the nursery, and this starts from the type of nutrient constituent of the top soil used for seedlings production, due to continuous scooping of topsoil in and around nurseries there is always loss or reduction of soil nutrients which lead to stunted growth, loss of vigor, susceptibility to pest and disease amongst others (Ogunlade et al., 2009). The soil must be rich in both micro and macro nutrients essential for cacao in other to have high vigor seedlings for field establishment (Yao et al., 2019). Farmers in time past had employed the use of many methods to improve soil nutrients used in the nursery; the use of synthetic fertilizers is one of the major means of enhancing the growth of seedlings throughout the world. Inorganic fertilizers had been in use to aid agricultural output in all forms of crop cultivation including cocoa (Saqib et al., 2020).

However, there are detrimental effects on the use of chemical or inorganic fertilizers such as pollution to underground water source, when allowed to run off into water sources may lead to eutrophication and ground water pollution. Their use may also lead to the destruction of soil structure when there is long usage by changing the soil pH, upset of beneficial microbial ecosystem, lead to pests increase and may even contribute to the release of greenhouse gases. Miah et al. (2004) opined that the use of synthetic fertilizers leads to the release of nitrate to underground water which at high concentration can immobilize some of the hemoglobin in blood when they directly or indirectly enter into human or livestock bodies. Nutrient imbalance is another side effect of inorganic fertilizers on the soil especially when they are excessively or continuously used, surface water contamination, chemical residue in food which may lead to deadly diseases like chronic kidney disease and this harmful effect may not manifest in humans for several years (Wimalawansa &Wimalawansa, 2014).

The report of Fanway Fertilizer Machinery (2019) also reveals that many types of inorganic fertilizers are highly acidic, which lead to increase in soil acidity, thereby reducing the population of beneficial organisms and eventually results into plants stunted growth. When inorganic or chemical fertilizers are continuously used, this may lead to build up of toxic chemicals in the soil such as arsenic, cadmium and uranium which are transported to the fruits and vegetables through the plant roots during nutrients uptake. Some of the extracts from plants materials that have been reported to enhance the growth of seedlings in order to avoid over-dependence on inorganic fertilizers include *Moringa oleifera*, *Aloe vera*, *Gliricidia sepium, Leucaena leucocephela*, and so on (Padmaja et al., 2009; Hamouda et al., 2012; Lema & Zeway, 2013; Ahmed et al., 2014; Emongor, 2014; El sherif, 2017; Hasan et al., 2017).

Holarrhena floribunda (G.) is a forest tree belonging to the family *Apocynaceae* due to its milky property secreted when its bark is cut or wounded, It is commonly called false rubber tree and 'Ako-Ire' in Yoruba language. It is a medium-sized tree, grows to the height between 4.5 to 15 meters, with shining leaves, which are up to 18 cm in length and up to 8cm in width, leaf consist of 6-12 pairs of lateral nerves (Orwa et al., 2009). There are two major recognized varieties which are; *var. floribunda* with glabrous or almost glabrous leaves and *var. tomentella* which has densely pubescent leaves and are commonly found in Sudan and Gambia (Ken Fern, 2014). *H. floribunda* has been found to be efficacious in treating various animal and human diseases such as treat nausea, abdominal pain, diarrhea, dysentery, malaria, diabetes and gonorrhea among others (Bayala et al., 2006; Badmus et al., 2014; Udoh et al., 2014; N'guessan et al., 2015).

Since many potting media and other mixes had been used as growing media to complement depleted soil in order to enhance the growth of cocoa seedlings in the nursery (Sosu, 2014), many exotic plants had been used as plant growth enhancers, but there is no tangible scientific report on the usage of indigenous plants such as *H. floribunda* as plant growth enhancer. Therefore, this study attempts to evaluate the effects of aqueous leaf extract of *H. floribunda* on the growth of cocoa seedlings in the nursery.

Materials and Methods

Experimental site

The experiment was conducted within the Nursery Section of Cocoa Research Institute of Nigeria (CRIN), Ibadan, Oyo State starting from August, 2019 to February, 2020. The site was located on Latitude 30 50" East of the Greenwich and Longitude 70 20"North of the equator in the humid tropical and rainforest zone of Nigeria, with annual rainfall ranging between 1200-1500mm and a daily average temperature of 30.1 °C.

Experimental design and methods

This experiment adopted Completely Randomized Design (CRD). One (1) kilogram each of sieved topsoil was weighed into perforated black polythene bags of 20.5 cm by 13.5 cm dimension; these were arranged in Completely Randomized Design (CRD) with Twenty-one treatments and were replicated three times. The cocoa beans planted were procured from CRIN and these included three selected varieties; CRIN TC1, CRIN TC3, and F3 AMAZON. There were three polythene bags per treatment, of which two seeds were sown per bag and later thinned to one seedling per polythene bag after sprouting; they were all arranged on thick polythene sheet to prevent their roots from tapping nutrient from the base soil.

Determination of the essential elements in *H. floribunda*

Fresh leaves of *H. floribunda* were collected from CRIN forest area and taken to Herbarium Section of Forestry Research Institute of Nigeria, Ibadan, Oyo State for proper identification. The leaf samples were rinsed with water, air dried and final drying was done in an oven at 68 ^{o}C. The samples were sequentially ground by electrical grinder for further analysis. The plant nutrients contents of fresh leaves of *H. floribunda* was determined using flame photometry method. 0.5 g of finely ground plant tissue was weighed into a quartz crucible, this was later placed in muffle furnace set at 500 $^{\circ}$C for 2 hours, the residue was moistened with water and 5 ml of HCl was slowly added. The solute was filtered through Whatman number 40 filter paper and the filtrate was collected into a 50 ml volumetric flask, the filtrate was further diluted with 50 ml of distilled water and shook very well. The presence of micro (Sodium, Zinc, Copper, Manganese and Iron) and macro (Phosphorus, potassium, calcium, magnesium and organic carbon) nutrients were determined calorimetrically and were estimated by triacid mixture (9: 4: 1 HNO_3: $HCl0_4$: H_2SO_4) and nitrogen content in the leaf sample was analyzed.

Leaf extracts preparations and application

The young fresh leaves of *H. floribunda* (Ako-ire) were thoroughly rinsed with running tap water in order to remove any bound particles and were allowed to air dry. One kilogram of fresh *H. floribunda* leaves were ground using electric grinder and soaked in One liter of water for twenty-four hours after which the plant mixture was sieved through a muslin cloth in order to get the stock solution. The stock was then diluted with water to different concentrations which were 1ml from extract with 10 ml of water (10% by volume); 1ml from extract with 20 ml of water (5% by volume); 1ml from extract with 30 ml of water (3.33% by volume); 1ml from extract with 40 ml of water (2.5% by volume); 1mil from Supergro with 1 L of water; 4 ml from CocoBoost with 1 L of water and water only as control, respectively. Leaves of the cocoa seedlings were directly sprayed with *H. floribunda* extract, Supergro and CocoBoost dilutions to run-off using a pressurized hand sprayer (2 liters model) at four (4) weeks after sprouting and regularly at two weeks interval for sixteen weeks (Modified method of Abusuwar & Abohassan, 2017).

Data collection and analysis

Plant growth parameters were measured at interval of two weeks for sixteen weeks, the parameters were plant height (in cm) using meter rule; stem girth (in cm) using digital Vernier calipers; leaf area (in cm^2) using leaf area meter; number of leaves by physical counting; root biomass using weighing scale and plant dried matter were weighed at sixteen weeks by destructive harvesting. Data collected were subjected to analysis of variance (ANOVA) using Statistical Analysis System 2013 package. While the treatment means were separated using Duncan Multiple Range Test (DMRT) at 5% level of probability.

Results

Essential plant nutrient present in *H. floribunda* leaves used as a plant growth enhancer

The result presented in Table 1 shows the presence of essential micro and macro plant nutrients contained in *H. floribunda* leaves as follows: Potassium (K) 0.70%, Calcium (Ca) 1.31%, Magnesium (Mg) 1.12%, Sodium (Na) 0.15%, Organic Carbon (C) 46.0%, Nitrogen (N) 3.61%, Manganese (Mn) 0.003%, Iron (Fe) 0.07%, Copper (Cu) 0.003%, Phosphorus (P) 0.10% and Zinc (Zn) 0.007%.

Table 1 Essential plant nutrient present in *H. floribunda* leaf extract used as Cocoa seedlings growth enhancer

Nutrient for plant growth	Amount (%)
Potassium	0.70
Calcium	1.31
Magnesium	1.12
Sodium	0.15
Zinc	0.007
Copper	0.003
Manganese	0.03
Iron	0.07
Organic carbon	46.0
Nitrogen	3.61
Phosphorus	0.10

The effect of aqueous leaf extract of *H. floribunda* on number of leaves of three varieties of cocoa seedlings

The assessment of aqueous leaf extract of *H. floribunda* (G.) at four different rates of applications on number of leaves of three varieties of cocoa seedlings is presented in Table 2 below. The average numbers of leaf recorded for CRINTC1, CRIN TC3 and F3 Amazon varieties at 4 Weeks After Sprouting (WAS) ranged between 5.55 -7.89, 5.78-7.55, and 5.88-7.78 respectively. The values increased to 12.67-15.11,12.22-14.22,and 12.33-16.11 respectively at 16WAS (Table 2).There were significant differences ($p<0.05$) in the effects of the different levels of concentrations of the extract and control with respect to the numbers of leaf of the three cocoa varieties throughout the experiment. At both 4and 6 weeks after sprouting(WAS) CRIN TC1 produced the highest mean values 7.89 and 9.56 of numbers of leaf respectively both at treatment 2, followed by F3 Amazon which were 7.78 and 9.55 at the application of treatment 1, though, the two treatments were not significantly different ($p>0.05$). While the least mean values 5.55 and 6.33 for numbers of leaf at 4 and 6WAS, respectively were recorded at treatment 7 (control) by CRIN TC 1.

F3 Amazon at 8, 10, 12, 14 and 16 WAS had the highest mean values 11.78, 12.67, 12.69, 14.11, and 16.11 of numbers of leaf at the application of treatment 1respectively while the least 8.44, 9.33 and 10.33 mean values of number of leaves were obtained at 8, 10 and 12WAS respectively for F3 Amazon at treatment 7 (control) while CRINTC3 at 14 and 16 WAS also had the respective least mean values 11.67 and 12.22 of numbers of leaf at treatments 7 (control).

Table 2 Effect of aqueous leaf extract of *H. floribunda* on number of leaves of three varieties of Cocoa seedlings

Treatment	4 WAS	6 WAS	8 WAS	10 WAS	12 WAS	14 WAS	16 WAS
V1T1	6.45^{b-d}	8.11^{b-d}	9.89^{b-e}	10.52^{b-c}	11.29^{a-d}	11.96^{b}	13.33^{b-c}
V2T1	7.55^{a-c}	8.55^{a-d}	11.00^{a-b}	11.67^{a-b}	12.00^{a-c}	12.44^{a-b}	13.89^{b-c}
V3T1	7.78^{a-b}	9.55^{a}	11.78^{a}	12.67^{a}	12.69^{a}	14.11^{a}	16.11^{a}
V1T2	7.89^{a}	9.56^{a}	11.00^{a-b}	11.56^{a-b}	11.96^{a-c}	12.26^{b}	13.78^{b-c}

V2T2	6.67^{a-d}	8.99^{a-c}	10.78^{a-c}	11.44^{a-b}	11.86^{a-d}	12.45^{a-b}	14.22^{a-c}
V3T2	6.44^{b-d}	9.33^{a-b}	11.00^{a-b}	9.44^{c}	11.55^{a-d}	12.56^{a-b}	14.33^{a-c}
V1T3	6.89^{a-d}	8.11^{b-d}	8.99^{d-f}	10.17^{b-c}	10.55^{c-d}	12.11^{b}	12.67^{c}
V2T3	6.45^{b-d}	7.78^{c-e}	8.00^{f}	10.73^{b-c}	10.90^{b-d}	11.85^{b}	12.33^{c}
V3T3	6.89^{a-d}	9.00^{a-c}	10.33^{a-d}	11.56^{a-b}	12.33^{a-b}	13.22^{a-b}	14.00^{b-c}
V1T4	5.67^{d}	7.56^{d-e}	10.22^{b-d}	11.11^{a-c}	11.89^{a-d}	12.61^{a-b}	15.11^{a-b}
V2T4	6.11^{d}	8.78^{a-d}	11.00^{a-b}	11.55^{a-b}	11.89^{a-d}	12.67^{a-b}	14.11^{a-c}
V3T4	6.67^{a-d}	8.44^{a-d}	10.45^{a-d}	11.78^{a-b}	12.34^{a-b}	12.67^{a-b}	13.45^{b-c}
V1T5	6.44^{b-d}	8.56^{a-d}	9.78^{b-e}	10.56^{b-c}	10.89^{b-d}	12.33^{b}	13.56^{b-c}
V2T5	5.89^{d}	8.11^{b-d}	9.33^{c-f}	9.99^{b-c}	10.34^{d}	12.45^{a-b}	13.89^{b-c}
V3T5	6.66^{a-d}	8.56^{a-d}	9.99^{b-d}	10.78^{b-c}	11.44^{a-d}	12.96^{b}	13.44^{b-c}
V1T6	6.17^{c-d}	7.67^{c-e}	9.00^{d-f}	10.11^{b-c}	11.11^{a-d}	12.22^{b}	13.56^{b-c}
V2T6	6.56^{a-d}	8.33^{a-d}	9.11^{d-f}	9.89^{b-c}	10.33^{d}	11.78^{b}	12.22^{c}
V3T6	6.56^{a-d}	7.67^{c-e}	9.67^{b-e}	10.78^{b-c}	11.56^{a-d}	13.25^{a-b}	14.11^{a-c}
V1T7	5.55^{d}	6.33^{f}	9.44^{c-f}	9.89^{b-c}	10.78^{b-d}	11.89^{b}	12.89^{c}
V2T7	5.78^{d}	6.66^{e-f}	8.44^{e-f}	9.45^{c}	10.33^{d}	11.67^{b}	12.33^{c}
V3T7	5.89^{d}	6.67^{e-f}	8.44^{e-f}	9.33^{c}	10.33^{d}	11.81^{b}	12.33^{c}

WAS = Weeks after sprouting; Mean with the same letter(s) along the same column are not significantly ($p<0.05$) different; V1 = CRINTC1; V2 = CRINTC3; V3 = F3 Amazon; T1 = 10% by volume of *H. floribunda*; T2 = 5% by volume of *H. floribunda*; T3 = 3.33% by volume of *H. floribunda*; T4 = 2.5% by volume of *H. floribunda*; T5 = Supergro concentration; T6 = CocoBoost concentration; T7 = Control

Effect of aqueous leaf extract of *H. floribunda* on heights of three varieties of Cocoa seedlings

Table 3 shows the effect of aqueous leaf extract of *H. floribunda* on heights of cocoa seedlings. The average mean values for plant heights obtained for CRIN TC1, CRIN TC2 and F3 Amazon varieties at 4 Weeks After Sprouting (WAS) ranged between 17.64-22.52, 16.90-19.73cm, and 16.55-22.80cm respectively. At 16 WAS, the values ranged from 28.93-33.30, 26.93-35.31cm, and 27.84-35.97cmfor CRIN TC1, TC2 and F3 Amazon respectively. There were significant differences ($p < 0.05$) in the effects of the different levels of concentrations of the extract on the plant height of the three cocoa varieties. At both 4and 6 WAS, the highest cm mean values 22.80 and 25.23 cm of plant heights were produced by F3Amazon respectively at application of treatment 1, followed in the same order by CRIN TC1 (22.52 and 24.31cm) when treatment 3 was applied.F3 Amazon and CRIN TC1 gave the least mean values 16.55 and 18.87 cm of plant heights at both 4 and 6 WAS respectively by treatment 7 (control).

CRIN TC1 had the highest mean value 26.67 cm of plant height at 8 WAS at the application of treatment 3, F3 Amazon, at 8WAS produced the least20.57cm mean value of plant heights at control. The highest mean values 30.17, 31.54, 32.33 and 35.97 cm 30.17, 31.54, 32.33 and 35.97cm of plant heights were produced by F3 Amazon at 10, 12, 14 and 16 WAS at the application of treatment 6, while the least mean values 22.12, 23.52 and 24.78 cm of plant heights at 10, 12and 14WAS were recorded by F3 Amazon and at 16WAS, CRIN TC2 produced the least mean value 27.73 cm of plant height all at treatment 7 (control).

Table 3 Effect of aqueous leaf extract of *H. floribunda* on height (cm) of the seedlings of three cocoa varieties

Treatment	4 WAS	6 WAS	8 WAS	10 WAS	12 WAS	14 WAS	16 WAS
V1T1	20.19^{bc}	23.68^{a-c}	26.16^{a-c}	29.60^{ab}	30.74^{ab}	32.07^{ab}	33.30^{a-c}
V2T1	18.52^{c-f}	21.55^{d-f}	22.79^{d-h}	29.01^{a-d}	29.84^{ac}	30.65^{a-e}	30.91^{c-j}
V3T1	22.80^{a}	25.23^{a}	26.43^{ab}	28.25^{a-e}	30.19^{a-c}	31.00^{a-d}	32.20^{b-e}
V1T2	21.04^{ab}	23.05^{b-d}	26.24^{a-c}	28.89^{a-d}	29.76^{a-c}	30.44^{a-e}	31.88^{c-g}
V2T2	19.18^{b-e}	21.48^{d-f}	23.34^{b-h}	25.18^{c-h}	27.05^{c-g}	27.96^{c-h}	28.79^{f-j}
V3T2	19.97^{b-d}	22.98^{b-d}	25.21^{a-f}	25.87^{b-h}	28.07^{a-f}	28.33^{b-h}	29.24^{e-j}
V1T3	22.52^{a}	24.31^{a}	26.67^{a}	29.24a-c	30.57^{a-c}	31.10^{a-d}	32.13^{b-f}
V2T3	19.49^{b-d}	22.49^{b-d}	25.59^{a-e}	27.48^{a-g}	28.74^{a-d}	30.00^{a-f}	31.13^{c-i}
V3T3	19.83^{b-d}	21.76^{c-e}	24.29^{a-g}	25.00^{d-h}	25.65^{d-g}	26.35^{f-h}	28.45^{h-j}
V1T4	18.06^{c-f}	23.01^{b-d}	25.17^{a-f}	26.38^{a-g}	27.11^{b-g}	28.65^{a-h}	30.29^{c-j}
V2T4	19.73^{b-d}	22.27^{dc}	25.07^{a-f}	25.73^{b-h}	26.94^{c-g}	27.41^{d-h}	28.73^{g-j}
V3T4	18.95^{b-f}	21.11^{d-g}	23.12^{c-h}	24.04^{f-h}	25.44^{d-g}	26.52^{f-h}	28.03^{ij}
V1T5	19.74^{b-d}	21.38^{d-f}	26.00^{a-d}	27.32^{a-g}	28.51^{a-e}	29.38^{a-g}	31.69^{c-h}
V2T5	19.67^{b-d}	21.89^{c-e}	22.35^{f-h}	24.33^{e-h}	24.97^{e-g}	27.04^{e-h}	29.17^{e-j}
V3T5	18.68^{b-f}	21.17^{d-g}	23.62^{a-h}	23.96^{h-f}	$24.77f^{g}$	$25.74g^{h}$	28.09^{ij}
V1T6	18.96^{b-f}	19.90^{e-h}	23.65^{a-h}	26.51^{a-g}	28.73^{a-d}	31.77^{a-c}	32.55^{b-d}
V2T6	18.63^{b-f}	19.20^{gh}	23.74^{a-h}	27.75^{a-f}	28.79^{a-d}	30.89^{a-e}	35.31^{ab}
V3T6	18.12^{c-f}	19.90^{e-h}	22.73^{e-h}	30.17^{a}	31.54^{a}	32.33^{a}	35.97^{a}

V1T7	17.64^{d-f}	18.87^{h}	21.23^{gh}	24.04^{f-h}	25.71^{d-g}	27.00^{e-h}	28.93^{e-j}
V2T7	16.90^{ef}	19.73^{f-h}	21.19^{gh}	23.39^{gh}	23.94^{g}	25.45^{h}	27.73^{ij}
V3T7	16.55^{f}	19.27^{gh}	20.57^{h}	22.12^{h}	23.52^{g}	24.78^{h}	27.84^{ij}

WAS = Weeks after sprouting; Mean with the same letter(s) along the same column are not significantly ($p<0.05$) different; V1 = CRINTC1; V2 = CRINTC3; V3 = F3 Amazon; T1 = 10% by volume of *H. floribunda*; T2 = 5% by volume of *H. floribunda*; T3 = 3.33% by volume of *H. floribunda*; T4 = 2.5% by volume of *H. floribunda*; T5 = Supergro concentration; T6 = CocoBoost concentration; T7 = Control

The effect of aqueous leaf extract of *H. floribunda* on stem girth of three varieties of cocoa seedlings

The effect of aqueous leaf extract of *H. floribunda* (HF) on stem girth of seedlings of three cocoa varieties is presented in Table 4. At 4 WAS the average mean values of stem girth for the three cocoa varieties CRIN TC1, CRIN TC3 and F3 Amazon ranged from 0.37-0.48 cm, 0.36-0.43 cm, and 0.38-0.46 cm, respectively, also at 16 WAS, the mean values were 0.81-0.95 cm, 0.79-0.99 cm, 0.75-0.99 cm, respectively. The result showed significant difference ($p<0.05$) in the mean effects on stem girth at all levels of concentrations of HF extract. At 4WAS, CRIN TC1 at the application of treatment 4 gave the highest mean value of 0.48cm, while CRIN TC3 gave the least mean value 0.36cm when treatment 7 was applied. CRIN TC3 at 6 WAS, had the highest mean value 0.65 cm of stem girth at the application of treatment 3 and CRIN TC1 gave the least mean value 0.49cm at the application of treatment 7 (control).

At 8 and 10 WAS the highest mean values 0.73 and 0.77 cm for stem girth were given by F3 Amazon both at treatment 1, while CRIN TC3 gave the least mean values 0.56 and 0.61cm at the application of treatments 5and 6 respectively. F3 Amazon had the highest mean value 0.84 cm at the application of treatment 5 while CRIN TC3 gave the least mean value 0.66 cm at treatment 7 (control) both at 12 WAS. The highest mean value 0.90 cm of stem girth at 14WAS was recorded at treatment 4 for CRIN TC3 while the least value 0.74 cm was recorded by F3 Amazon at treatment 7. CRIN TC3 at the application of treatment 5 had the highest value 0.99 cm of stem girth while F3 Amazon had the least value 0.75 cm of stem girth at the application of treatment 7 (control) both at 16 WAS.

Table 4 Effect of aqueous leaf extract of *H. floribunda* on stem girth (cm) of the seedlings of three cocoa varieties

Treatment	4 WAS	6 WAS	8 WAS	10 WAS	12 WAS	14 WAS	16 WAS
V1T1	0.45^{a-c}	0.61^{a-d}	0.69^{a-c}	0.73^{ab}	0.79^{ab}	0.84^{a-f}	0.92^{a-c}
V2T1	0.36^{f}	0.52^{fg}	0.56^{b-d}	0.640^{c-e}	0.83^{a}	0.81^{b-g}	0.91^{a-c}
V3T1	0.42^{a-e}	0.64^{a}	0.73^{a}	0.77^{a}	0.78^{bc}	0.89^{a-b}	0.98^{a}
V1T2	0.44^{a-d}	0.59^{a-e}	0.65^{b-d}	0.74^{a}	0.80^{a-b}	0.87^{a-e}	0.93^{a-c}
V2T2	0.38^{d-f}	0.59^{a-f}	0.67^{a-d}	0.73^{a-b}	0.76^{a-c}	0.83^{a-f}	0.97^{a-b}
V3T2	0.46^{ab}	0.58^{a-f}	0.70^{ab}	0.74^{a}	0.81^{a}	0.85^{a-e}	0.94^{a-c}
V1T3	0.46^{a-b}	0.63^{a-b}	0.65^{b-e}	0.74^{a}	0.78^{a-b}	0.87^{a-d}	0.93^{a-c}
V2T3	0.41^{b-f}	0.65^{a}	0.69^{a-c}	0.73^{a-c}	0.79^{a-b}	0.88^{a-c}	0.98^{a}
V3T3	0.42^{a-e}	0.61^{a-c}	0.67^{b-d}	0.72^{a-c}	0.78^{a-b}	0.83^{a-f}	0.94^{a-c}
V1T4	0.48^{a}	0.59^{a-e}	0.64^{b-e}	0.70^{a-d}	0.79^{a-b}	0.82^{a-g}	0.95^{a-c}
V2T4	0.42^{a-e}	0.61^{a-c}	0.66^{b-e}	0.69^{a-e}	0.82^{a}	0.90^{a}	0.59^{a-b}
V3T4	0.42^{a-e}	0.63^{a-c}	0.66^{b-e}	0.69^{a-e}	0.78^{a-b}	0.82^{a-g}	0.90^{a-c}
V1T5	0.44^{a-d}	0.59^{a-d}	0.65^{b-e}	0.69^{a-e}	0.74^{a-c}	0.84^{a-f}	0.94^{a-c}
V2T5	0.39^{b-f}	0.58^{a-f}	0.55^{b-e}	0.69^{a-e}	0.78^{a-b}	0.89^{a-b}	0.99^{a}
V3T5	0.45^{a-b}	0.58^{a-f}	0.66^{b-e}	0.73^{a-b}	0.84^{a}	0.83^{a-f}	0.94^{a-c}
V1T6	0.38^{c-f}	0.56^{b-g}	0.65^{b-e}	0.69^{a-d}	0.76^{a-c}	0.82^{a-g}	0.91^{a-c}
V2T6	0.43^{a-e}	0.55^{c-g}	0.63^{c-f}	0.61^{e}	0.75^{a-c}	0.80^{c-g}	0.87^{b-d}
V3T6	0.38^{c-f}	0.58^{a-f}	0.62^{d-g}	0.65^{b-e}	0.70^{bc}	7.77^{e-g}	0.85^{d-c}
V1T7	0.37^{e-f}	0.49^{g}	0.59^{e-g}	0.65^{b-e}	0.70^{bc}	0.78^{d-g}	0.81^{de}
V2T7	0.36^{e-f}	0.52^{e-g}	0.58^{fg}	0.61^{de}	0.66^{c}	0.76^{fg}	0.79^{de}
V3T7	0.38^{c-f}	0.53^{d-g}	0.59^{e-g}	0.65^{b-e}	0.67^{c}	0.74^{g}	0.75^{e}

WAS = Weeks after sprouting; Mean with the same letter(s) along the same column are not significantly ($p<0.05$) different; V1 = CRINTC1; V2 = CRINTC3; V3 = F3 Amazon; T1 = 10% by volume of *H. floribunda*; T2 = 5% by volume of *H. floribunda*; T3 = 3.33% by volume of *H. floribunda*; T4 = 2.5% by volume of *H. floribunda*; T5 = Supergro concentration; T6 = CocoBoost concentration; T7 = Control

The effect of aqueous leaf extract of *H. floribunda* on leaf area of three varieties of cocoa seedlings

Table 5 presents the effect of aqueous leaf extract of *H. floribunda* on leaf area of three varieties of cocoa seedlings (CRIN TC1, CRIN TC3, and F3 Amazon). The average mean values for leaf area for the three varieties at 4WAS ranged as follows; 45.86-64.66 cm^2, 48.98-63.96 cm^2 and 43.61-58.38 cm^2, respectively. At 16 WAS the values increased to 90.95-110.73 cm^2, 97.31-125.44 cm^2 and 87.64-118.02 cm^2, respectively. At 4 WAS, CRIN TC1 at the application of treatment 3 had the highest mean 64.66 cm^2 leaf area, while F3 Amazon when treatment 7 (control) was applied gave the least mean value 43.61 cm^2 of leaf area. At 6 WAS, CRIN TC3 produced the highest mean value (71.51 cm^2) of leaf area when treatment 3 was applied, while F3 Amazon had the least mean value (46.62 cm^2) of leaf area when treatment 7 (control) was applied.

At 8 WAS, the highest and the least mean values 84.09 cm^2 was produced by CRIN TC3 at the application of treatments 2 while the least mean value 61.64 cm^2 was produced by CRIN TC2 at the application of treatment 6. F3 Amazon at treatment 1 has the highest mean value 103.59 cm^2 and CRIN TC1 at treatment 7 (control) had the least mean values 68.26 cm^2 of leaf areas both at 10 WAS. At 12 WAS, CRIN TC1 produced both the highest (105.31cm^2) and least mean values 72.66 cm^2 of leaf area at treatments 2 and 7, respectively. At 14 and 16 WAS, CRIN TC3 at the application of treatments 3 and 2 produced the highest mean of 117.31cm^2 and 125.44 cm^2 leaf area, respectively, while F3 AMAZON at the application of treatment 7 (control) and treatment 6 gave the least mean of 74.10 cm^2 and 87.64 cm^2 of leaf areas, respectively.

Table 5 Effect of aqueous leaf extract of *H. floribunda* on leaf area (cm^2) of the seedlings of three cocoa varieties

Treatment	4 WAS	6 WAS	8 WAS	10 WAS	12 WAS	14 WAS	16 WAS
V1T1	60.14^{a-d}	69.55^{ab}	79.55^{a-c}	85.79^{b-g}	94.86^{a-c}	105.24^{bc}	110.73^{a-d}
V2T1	59.68^{a-d}	66.13^{a-d}	77.88^{a-d}	87.39^{b-f}	100.87^{a-b}	109.91^{a-b}	116.33a-c
V3T1	58.38^{a-d}	68.88^{a-c}	83.91^{a}	103.59^{a}	104.87^{a}	115.21^{a-b}	118.02^{ab}
V1T2	52.33^{d-g}	56.77^{e-h}	71.05^{b-e}	95.39^{a-c}	105.31^{a}	112.70^{a-b}	104.67^{a-d}
V2T2	63.08^{a-c}	69.14^{ab}	84.09^{a}	99.56^{ab}	104.59^{a}	109.23^{ab}	125.44^{a}
V3T2	56.48^{a-e}	62.12^{b-f}	83.40^{a}	91.78^{a-c}	93.67^{a-d}	104.51^{b-d}	109.22^{a-d}
V1T3	64.66^{a}	68.81^{a-c}	71.38^{b-e}	89.25^{a-d}	85.02^{b-e}	94.14^{d-f}	110.45^{a-d}
V2T3	63.96^{ab}	71.51^{a}	81.42^{ab}	88.87^{a-e}	93.06^{a-d}	117.31^{a}	122.20^{ab}
V3T3	56.18^{b-f}	64.14^{a-d}	69.33^{c-e}	81.49^{c-h}	84.56^{b-e}	91.53^{e-g}	111.03^{a-d}
V1T4	55.93^{b-f}	63.14^{a-f}	70.06^{c-e}	73.38^{e-h}	81.15^{c-e}	96.12^{c-e}	109.22^{a-d}
V2T4	58.06^{a-d}	66.70^{a-d}	69.44^{c-e}	73.34^{e-h}	78.07^{c-e}	90.21^{e-f}	106.31^{a-d}
V3T4	52.64^{d-g}	59.87^{d-g}	68.23^{c-e}	71.00^{gh}	86.32^{b-e}	85.31^{e-g}	98.02^{b-d}
V1T5	58.74^{a-d}	64.69^{a-d}	69.65^{c-e}	72.05^{f-h}	76.59^{c-e}	84.44^{f-h}	90.95^{d}
V2T5	55.54^{c-f}	62.12^{b-f}	66.56^{de}	70.11^{gh}	79.46^{c-e}	95.01^{c-f}	120.02^{ab}
V3T5	53.91^{d-g}	59.30^{d-g}	69.41^{c-e}	76.13^{d-h}	82.36^{c-e}	85.88^{e-g}	93.06^{cd}
V1T6	55.73^{b-f}	60.21^{c-g}	67.61^{de}	74.37^{d-h}	79.78^{c-e}	86.30^{e-g}	102.83^{a-d}
V2T6	53.51^{d-g}	58.95^{d-g}	61.64^{e}	73.14^{f-h}	75.98^{de}	92.63^{e-g}\	105.51^{a-d}
V3T6	48.13^{f-h}	53.26^{g-i}	63.15^{e}	74.05^{d-h}	79.16^{c-e}	84.18^{f-h}	87.64^{d}
V1T7	45.86^{gh}	50.29^{hi}	62.08^{e}	68.26^{h}	72.66^{e}	82.32^{gh}	92.29^{cd}
V2T7	48.98^{e-h}	54.49^{f-i}	66.53^{de}	76.47^{d-h}	78.78^{c-e}	82.40^{gh}	97.31^{b-d}
V3T7	43.61^{h}	46.62^{i}	65.56^{e}	74.76^{d-h}	76.96^{c-e}	74.10^{h}	90.85^{d}

WAS = Weeks after sprouting; Mean with the same letter(s) along the same column are not significantly ($p<0.05$) different; V1 = CRINTC1; V2 = CRINTC3; V3 = F3 Amazon; T1 = 10% by volume of *H. floribunda*; T2 = 5% by volume of *H. floribunda*; T3 = 3.33% by volume of *H. floribunda*; T4 = 2.5% by volume of *H. floribunda*; T5 = Supergro concentration; T6 = CocoBoost concentration; T7 = Control

Discussion

The result of this study showed that the extract of *H. floribunda* contained micro and macro nutrients which are capable of enhancing agricultural soil. This outcome is in line with that of Bakhsh et al. (2020) indicating that the use of organic foliar fertilizers could increase soil nutrients. This is also consistent with the submission of Liu et al (2019) that addition of organic substance to the soil could enhance crop productivity. In the same vein, *H. floribunda* at varied concentrations had a significant effect on the vegetative growth of seedlings of selected varieties of cocoa. It implies that the aqueous leaf extract of *H. floribunda* can be used as an organic growth enhancer for cocoa seedlings just like other plant extracts from shrubs or trees such as *Moringa oleifera* which was reported to have enhanced the vegetative growth; disease and pest resistance and yield of tomato; peanut, wheat and corn when applied as foliar spray (Culver et al., 2012). Also, this is in agreement with the work of Hasan et al. (2017) which revealed that the application of *Moringa oleifera* leaves extract when used as foliar spray effectively enhanced seed germination and seedling vigour of cowpea.

The use of conventional or synthetic fertilizers had been an effective measure for enhancing the growth and development of crops but these synthetic or inorganic fertilizers pose a detrimental effect on the health of all consumers of these crops because of accumulation of heavy metals in the produce which has been found to be carcinogenic. More so, the excess chemicals, when leached into the water bodies surrounding the points of application lead to contamination of water bodies which might result into death of aquatic animals in such water (Fagbohun & Lawal, 2011). Also, the report of Miah, et al. (2004) revealed that when inorganic fertilizers are used, it can lead to water pollution through the release of nitrate into underground water. To this end, the use of aqueous leaf extract of *H. floribunda* (G.) stands to serve as a safe and effective plants growth enhancer particularly cocoa seedlings due to its economic demand and relevance. Although, there is dearth of literature on the effect of spraying aqueous leaf extract of *H. floribunda* on growth of cocoa varieties seedlings or other related crops, the present study has provided base line information on the effectiveness of aqueous leaf extract of *H. floribunda*.

The outcome of this study is in line with other studies carried out on the use of other plant extracts as growth enhancers. For instance, the findings of Hamouda et al. (2012); El Sherif (2017) revealed that *Aloe vera* leaf extract enhanced the growth of Populus trees grown under *in vitro* condition. The highest number of leaves as observed in all concentration of *H. floribunda* compared to control (0%) could be as a result of the presence of high level of phosphorus in *H. floribunda* extract with which this could have accounted for leaf formation resulting to higher number of leaves as reported by Assa et al. (2013); Kadir et al. (2016) that the presence of high content of phosphorus in orange and Banana peels has the potential to increase leaf formation respectively.

The plant height of the three varieties of cocoa seedlings was observed to be enhanced by aqueous leaf extract of *H. floribunda* and the result showed a favorable competition with other organic growth enhancers used as positive control for the study. This outcome supported the work of Abdel-Mawgoud et al. (2010); Ambika and Sujatha (2016) on the use of seaweed extract as growth enhancer for pigeon pea. The increase in plant height by seaweeds might be due to seaweed extracts improve the absorption of nutrients through the roots causing additional and strong overall growth of the plant. Spraying of seaweed extracts on critical growth stages which was effectively utilized by the crop and expressed in higher growth and yield attribute.

Conclusion

The finding also revealed that aqueous leaf extract of *H. floribunda* was effective in enhancing the vegetative growth (number of leaves, plant height, stem girth and leaf area) of the three varieties of cocoa seedlings at varying concentrations (10, 5, 3.33 and 2.5%). Although, 10% concentration of the plant extract proved most effective. It was also revealed that among the three cocoa varieties used for this study, F3 Amazon responded most to the growth enhancing effect of *H. floribunda*. It can be concluded from the foregoing, that aqueous leaf extract of *H. floribunda* can be adopted by researchers and farmers as plant growth enhancer because of its potential in promoting organic farming and reduction in environmental footprint of agricultural practices.

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