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COCOA TREES (*THEOBROMA CACAO* LINN.) AGROFORESTS REPLANTING IN TOGO: WHAT APPROPRIATE AGROECOSYSTEMS?

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ABSTRACT

Cocoa agroforest remained the main cultivated agroforest in West Africa. This study examined the effects of shading regime, soil depth and soil texture on the growth of immature cocoa trees. A field experiment was conducted during one year in forest zone in Togo and data was collected in twelve cocoa orchards established in June - July 2014. Three equal size plots (12 x 10 m²) were randomly located in each orchard, where agronomic variables and soil samples were collected. The results showed that, more the shading regime was dense ($p<0.05$) more the young cocoa trees crown were developed, more the crown radius were extended and less the cocoa trees died. When the orchard soil was deeper ($p<0.05$), better the cocoa trees used rainwater and more quickly they were developed. The cocoa trees mortality rate was less when the soil texture was sandy-loam ($p<0.05$) and more numerous were the crowns formed. The optimum condition for immature cocoa trees growth was an agroecosystem who meet a sandy-loam soils, deep more than one meter and covering by a shading trees which prevent from 75-100% of sunlight.

INTRODUCTION

The cocoa, known as the gods food (*Theobroma cacao* L.), is a cash crop in many tropical countries and the most widespread land use system in the Guinean rain forest of West Africa (Gockowski and Sonwa, 2011) including Togo. Compared to other farming activities, the cocoa production has always been considered as a leading sub-sector in the economic growth and development of several West African countries (Duguma *et al*., 2001). The global demand of cocoa was constantly rising from 3.7 million tons in 2008 to 4.052 million tons in 2013 while the global cocoa production rose from 3.7 million tons in 2008 to 3.931 million tons in 2013 (ICCO, 2008 and 2013). The offer was not in line with the demand; a situation that resulted in the rise of the cocoa global prices since some time. Africa still has a cocoa production monopoly with more than 70 % of the cocoa global supply (Wessel and Quist-Wessel, 2015) and there are still opportunities to increase the production by around 9% (Aikpokpodion, 2010).

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Therefore, the smallholders' farmers, who supplied the majority of the cocoa production in Africa, have embarked on a replanting cocoa orchard in order to meet the growing demand. Several authors have worked on the optimal or critical agro-ecological conditions of the cocoa production in the soil-plant-atmosphere system. The soils under the cocoa trees have very pronounced requirements (Koko *et al*., 2009). The rainfall regime for the cocoa trees success growth is estimated between 1000 and 2000 mm.year^{-1} with less than three months of rainfall less than 100 mm and a temperature from 18-32°C (Oro, 2011; Koko, 2014). The soil should be at least 1.5 m deep, well drained and preferably sandy-loam (Koko, 2014). Other soil chemical properties were also required in terms of organic matter content (≥30 g.kg^{-1}), pH (6-7.5) and content of nitrogen (≥1 g.kg^{-1}), phosphorus (30-100 ppm), potassium (≥100 ppm or ≥1.2 cmol.kg^{-1}), calcium (≥5-8 cmol.kg^{-1}) and magnesium (≥0.8 cmol.kg^{-1}) with a Cation Exchange Capacity (CEC) of 20 cmol.kg^{-1} at least (Aikpokpodion, 2010; Koko, 2014; Akanbi *et al*, 2014). In Togo, as part of the boosting of the coffee and cocoa sectors with the Project PASA (Projet d'Appui au Secteur Agricole) started since 2013, the farmers have rushed into reconverting the plantations and spaces available into cocoa plantations.

The cacao orchards are planted in any agroecosystem. However, the management of the soil fertility under the cocoa trees in Togo is based on the use of multipurpose agroforestry trees (Koudjega *et al*., 2010). In cocoa trees agroforests with shading, nutrients recycling process, soil fertility and pods production are favoured well than the systems without shading (Ofori-Frimpong *et al*., 2003; Utomo *et al*., 2015). Comparative tests of the cocoa trees with or without shading showed that the cocoa trees grown in full-sun farming could produce cocoa twice than cocoa trees under shading. But the cocoa trees life under shading is deemed longer than those grown in full sunlight (Myers *et al*., 2000; Snoeck, 2010; Tondoh *et al*, 2014). The optimum farming environment for the cocoa tree was the forest (Gockowski and Sonwa, 2011), but an increasing number of farmers have started planting the cocoa trees under a non-forest environment (old cocoa or coffee orchards, natural fallow) with all the risks of failure (Deheuvels, 2007; Koko, 2014). In the cocoa production zones, the agroforestry systems were having a dense plant cover (>60%) provided by a variety of trees from previous forest (Bos *et al*., 2007; Faria and Baumgarten, 2007; Sonwa *et al*. 2007). The farming environment "forest" offers to the cocoa orchard benefits in terms of soil fertility and shading against the sun acting as a temperature buffer (Beer *et al*., 1998). With the production conditions underlying the boom of cocoa trees orchards renewing in Togo, it is essential to assess the cocoa trees adaptability to the new agro-ecological conditions imposed on them. Therefore, this study aims to determine the effects of agroforestry trees shading, soil depth and soil texture on the growth of the young cocoa trees then to assess the water use efficiency in the current cocoa trees replanting conditions.

MATERIAL AND METHODS

Study zone

This study was conducted in the agro-ecological forests zone at the feet of Akposso Mountains in the District of Amou, located in the Western part of the Plateaux region in Togo. This is an area with a rainfall varying between 1200 and 1600 mm per year with an average temperature of 20-35°C. The soil in place is ferruginous with clay dominance and rich in organic matter (55 $g.kg^{-1}$), poor in nitrogen (2 $g.kg^{-1}$) and phosphorus (21.9 $mg.kg^{-1}$). The exchangeable bases content are low (0.3 K meq%, 13.4 Ca meq% and 5.9 Mg meq %) with CEC of 21.1 meq % and a pH of 6.7 (Koudjega and Tossah, 2009).

Selection and management of experimental groves

In the zone, twelve (12) cocoa orchards established in peasant area were selected for this study (Table 1). The orchards were selected based on the agroforestry trees density on the plot prior to the plantation establishment. These plantations were created and managed with the support of the Agricultural Advisors from ICAT (Institut de Conseil et d'Appui Technique). The test was conducted over a year. The plantations creation was made by keeping the existing trees on the plots. The orchards were created in June-July 2014 with the cocoa seedlings to be planted at an average height of 30±2.9 cm and stem girth size of 2±0.2 cm with 5±1 pairs of leaves. The creation chart was 3 x 2.5 m² (1320 $plant.ha^{-1}$) into holes of 0.40 x 0.40 x 0.40 m^3. The cocoa tree variety used is a hybrid mixture tolerant to Swollen Shoot composed of the following hybrids: P_7 Imc_{67}x (18%), Imc_{67}x P_7 (18%), P_{A7} x P_7 (17%), P_{A7} x P_{30} (17%), P_7 x $T_{60/887}$ (15%) and $T_{60/887}$ x P_7 (15%). The management of the young cocoa trees was similar with manual weeding and suckering as well as the phytosanitary treatments once a quarter. No fertilizer has been applied to the cocoa trees.

Data collection

For the demarcation of the plots, the approach used by Adekunle *et al*. (2011) was replicated. Three plots of the same size (12 x 10 m²) were demarcated in each of the twelve (12) selected cocoa orchards. The experimental lied out in a completely randomized design. For the production conditions characterization of the young cocoa trees, the soil-plant-atmosphere approach was used. The focus was on the soil properties (soil texture and soil depth), the cocoa trees vegetation cover (shading density) and the climate properties (rainfall and water use efficiency). The measurements were taken on all agroforestry trees and five young cocoa trees in each plot. On the agroforestry trees, the crown radius was measured to calculate the coverage rate at the plot ground. On the young cocoa trees, the height was measured (from the stump to the top of the plant), the stem diameter at the stump, the stem diameter at 1 m height, the number of crown formed in the plot and the crown radius. In order to assess the use of water resources, the cocoa trees annual elongation feet and the cocoa trees water use efficiency were determined. Trenches were dug in the plots to determine the depth of the soil in place and the soil composite samples (depth of 0-30 cm) were taken to determine the soil texture in laboratory.

Table 1. Studied locations

Site N°	Village	Geo-reference coordinate			Orchards surface, ha
		Latitude	Longitude	Altitude	
1	Adjahun	07°29'06,8''	000°55'36,9''	309 m	1.00
2	Dédomé	07°30'26,2''	000°59'03,1''	283 m	0.50
3	Dédomé	07°80'19,2''	000°58'59,1''	272 m	300
4	Dédomé Ferme	07°27'54,6''	000°58'20,8''	203 m	0.50
5	Kodzo Aza	07°36'03,6''	001°02'08,5''	283 m	0.25
6	Amlamé	07°27'83,2''	000°54'60,7''	296 m	0.60
7	Dédomé Ferme	07°28'54,6''	000°57'46,2''	218 m	0.50
8	Dédomé	07°30'08,6''	000°58'91,8''	279 m	1.00
9	Kpètè	07°25'04,8''	000°53'08,3''	293 m	0.50
10	Amlamé	07°27'79,0''	000°54'08,9''	304 m	1.00
11	Amlamé	07°27'76,4''	000'54'28,7''	297 m	0.06
12	Amlamé	07°27'77,1''	000°54'59,6''	295 m	0.13

Data analysis

For analysis purposes of the collected data, the studied factors were grouped into class. For the shading, four classes were defined based on the shading density offered by the forest trees to the cocoa trees. These classes are expressed in percentage (%): [0-25[, [25-50[, [50-75[and [75-100]. For the soil, the trenches depth is stratified into three classes (<0.8 m, between 0.8-1 m and >1 m) as well as the soil texture (sandy-clay, silty-loam and sandy-loam). In each orchard, the arithmetic averages were determined with the data collected on the agronomic variables measured in the three plots. The stem girth size at stump, as at 1 m height, was calculated by multiplying the diameter of the plants determined at each level by π (3.142). The formation of the crown is expressed by the percentage of the cocoa tree feet having formed their crown after a year growth. The cocoa trees crown radius is the average of three measurements of the horizontal distance on the ground from the foot of the tree to the tips of the branches. The cocoa trees growth speed, expressed by the annual elongation, was determined. The annual elongation is determined from the difference between the cocoa trees height after a year growth and their average height at the planting time. The water use efficiency is provided by the ratio of the annual elongation on the rainwater amount received over an area of one hectare of cocoa trees. The analysis of variance (ANOVA) was made and the separation of homogeneous groups by the Duncan multiple test range performed with the STATISTICA software version 5.5 at the 5% threshold.

RESULTS

Effects of the agroforestry trees shading on the young cocoa trees growth

In average, the cocoa trees height is 94.80±8.58 cm, the stem girth at the stump is 6.85±2.72 cm and their stem girth at 1 m height is 2.46±3.25 cm (Table 2). The shading density had no impact on the cocoa trees height ($F_{(8, 12)}$=3.361; p =0.076), on the stem girth at the stump ($F_{(8, 12)}$= 2.883; p =0.103) and on the stem girth at 1 m height ($F_{(8, 12)}$= 2.500, p =0.133). For shade regime between 0 and 25 %, the mortality of the young cocoa trees is estimated on average at 71±19 %, while the other shading classes show mortality relatively less important (17±12 % to 19±6 %).

The shading provided by the agroforestry trees has a significant influence ($F_{(8, 12)}$=17.109, p=0.001) on the young cocoa trees mortality. Therefore, this indicates that the denser the shading is, the lesser the mortality in the young cocoa trees is. Only 27±12 % of the cocoa trees have developed their crown after a year growth when the shading level is between 0 and 25 % against from 67±12 % to 67±31 % of crowns developed between 25 and 75% of shading. It is also worth noting that 100% of crowns are developed when the shading level is between 75-100%. The shading density has a significant influence on the development of the crown on the young cocoa trees ($F_{(8, 12)}$=9.000, p=0.006). The denser the shading is, the more developed the crown on the cocoa trees after a year of growth is. For coverage between 0 and 25% of the shade regime, the crown radius is less extensive (29.07±4.11 cm). The shade regime of 25-50% and 50-75% show crown radius of the same size (34.07±4.15 cm and 33.80±6.08 cm, respectively). The shade regime of 75-100% gives the best crown radius with an average of 41.87±3.30 cm. The effect of the shading on the cocoa trees crown radius follows the same statistical variation as the crown formation ($F_{(8, 12)}$=4.113; p=0.049). The denser the shading is, the larger the crown radius is.

Effects of the soil depth on the young cocoa trees growth

Regardless of soil depth, the cacao trees mortality ratio in average is 29±26 % (Table 3), the stem girth at the stump revealed 6.85±2.72 cm, the stem girth at 1 m height gives 2.46±3.25 cm; 67±31 % of the cocoa trees develop their crown and the young cocoa trees crown radius show 35.02±6.16 cm. The soil depth under the cacao trees has no impact on the young cocoa trees mortality ($F_{(8, 12)}$= 1.366, p =0.303), on the stem girth at the stump ($F_{(8, 12)}$=2.087; p=0.180), on the stem girth at 1 m height ($F_{(8, 12)}$=1.633; p =0.248), on the crown formation ($F_{(8, 12)}$=1.272; p=0.326) and on the crown radius ($F_{(8, 12)}$= 1.260; p=0.329). At a depth less than 0.8 m and between 0.8-1 m, the cocoa trees height is 89.95±9.64 cm and 92.76±3.69 cm, respectively. At a soil depth higher than 1 m, the cocoa trees are longer and give an average of 104.67±5.85 cm. The depth of the soil under the cacao trees has a significant influence on the cocoa trees height ($F_{(8, 12)}$=4.555, p=0,0,043). Consequently, the deeper the soil is the faster the cocoa trees growth in height.

Table 2. Effect of shading regime on the young cocoa trees growth

Agronomic variables	Shading classes level (%)						
	[0-25[	[25-50[	[50-75[	[75-100]	Means	F	p
Mortality rate, %	71±19[b]	18±6[a]	17±12[a]	19±6[a]	31±26	17.109	0,001
Plants height, cm	86.00±3.12[a]	92.27±6.05[a]	99.40±9.66[a]	101.53±6.27[a]	94.80±8.58	3.361	0.076
Stem girth at stump, cm	5.49±1.36[a]	6.62±0.64[a]	7.25±3.89[a]	8.60±1.50[a]	6.85±2.72	2.883	0.103
Stem girth at 1 m high, cm	1.89±0.00[a]	1.78±3.22[a]	2.93±4.17[a]	4.48±1.50[a]	2.46±3.25	2.500	0.133
Crown formation, %	27±12[b]	67±12[a]	67±31[a]	100±0[a]	65±31	9.000	0.006
Crown radius, cm	29.07±4.11[b]	34.07±4.15[ab]	33.80±6.08[ab]	41.87±3.30[a]	34.70±6.16	4.113	0.049

The means on the same line affected by a same letter are not significantly different with ANOVA and Duncan test

Table 3: Effect of sol depth on the young cocoa trees growth

Agronomic variables	Soil depth, m					
	< 0,8	0,8 - 1	> 1	Means	F	p
Mortality rate, %	42±26[a]	35±31[a]	11±3[a]	29±26	1,366	0.303
Plants height, cm	89.95±9.64[b]	92.76±3.69[b]	104.67±5.85[a]	95.79±8.58	4.555	0.043
Stem girth at stump, cm	6.44±3.08[a]	6.42±1.01[a]	8.12±3.40[a]	6.85±2.72	2.087	0.180
Stem girth at 1 m high, cm	2.04±3.61[a]	2.55±1.76[a]	4.11±4.13[a]	2.46±3.25	1.633	0.248
Crown formation, %	50±38[a]	64±26[a]	87±23[a]	67±31	1.272	0.326
Crown radius, cm	31.45±7.69[a]	34.88±3.41[a]	38.73±7.13[a]	35.02±6.16	1.260	0.329

The means on the same line affected by a same letter are not significantly different with ANOVA and Duncan test.

Effects of the soil texture on the young cocoa trees growth

Whatever the soil texture, the cocoa trees have an average height of 89.31±8.58 cm, a stem girth at the stump of 5.97±2.72 cm, a stem girth at 1 m height of 2.26±3.25 cm and a crown radius of 31.13±6.16 cm (Table 4). The texture of the soil under the cocoa trees has no significant influence on the cocoa trees height ($F_{(8, 12)}$=3.088, p =0.095), on the stem girth at the stump ($F_{(8, 12)}$=3.123; p =0.093), on the stem girth at 1 m height ($F_{(8, 12)}$=0.539; p =0.601) and on the crown radius ($F_{(8, 12)}$=2.217; p=0.165). On the sandy-clay soil, the mortality rate is 69±27 % and on the silty-loam soil the mortality rate is 75±0 %. The sandy-clay and silty-loam soils show a high influence on the cocoa trees mortality and are in the same homogeneous group. The sandy-loam soil only gives a mortality rate of 18±7 %. Therefore, the cocoa trees better resist on the sandy-loam soils. Regarding the crown formation, the silty-loam soils are proven to be less favourable for the cocoa trees with a crown formation rate of 20±0 % followed by the sandy-clay soils which have an average rate of 30±14 % of crown formation. The sandy-loam soils further promote the crown formation with a rate of 78±23 %. Therefore, the sandy-loam soils are more likely to contribute to the cocoa trees crown formation after a year growth. The three textures of the identified soils under the studied cocoa trees have significant influence variable on the mortality rate of the cocoa trees ($F_{(8, 12)}$=24.290, p=0.000) and the crown formation ($F_{(8, 12)}$=5.872; p=0.023).

Young cocoa trees growth rate and use of water resources

The cocoa trees growth speed resulted in the annual elongation of the plant. In average, the cocoa trees growth rate is 64.80±8.58 $cm.an^{-1}$ regardless of the shading density and 59.31±8.58 $cm.an^{-1}$ regardless of the soil texture (Table 5). The shading of the agroforestry trees ($F_{(8, 12)}$ = 3.361, p = 0.076) and the soil texture ($F_{(8, 12)}$=3.088, p=0.095) have no impact on the annual elongation of the cocoa trees. However, the soil depth has a significant influence on the annual elongation ($F_{(8, 12)}$= 4.555, p=0.043). The cocoa trees best growth rate is obtained with a soil depth more than 1 m (74.67±5.85 $cm.an^{-1}$). Below 1 m soil depth, the growth rate is more moderate (between 59.95±9.64 $cm.an^{-1}$ and 62.76±3.69 $cm.an^{-1}$). Therefore the deeper the soil is, the faster the cocoa trees growth is. In average, the water use efficiency is 5.96±0.79 $cm.m^{-3}$ for the shading and 5.46±0.79 $cm.m^{-3}$ for the soil texture. This means that 1 m^3 of the rainfall can yield about 5.5-6 cm of the cocoa plants elongation regardless of the shading density and the soil texture. Whatever the shading density and the soil texture, the cocoa trees used water in the same manner. The water use efficiency is influenced neither by the shading density ($F_{(8, 12)}$ = 3.363; p = 0.076) nor the soil texture ($F_{(8, 12)}$ =3.107, p=0.094). The water use efficiency varies on average between 5.52±0.89 $cm.m^{-3}$ and 5.78±0.34 $cm.m^{-3}$ while the soil depth is respectively less than 0.8 m and between 0.8-1m. At a soil deeper than 1 m, the water use efficiency is the best with an average of 6.87±0.54 $cm.m^{-3}$.

Table 4. Effect of sol texture on the young cocoa trees growth

Agronomic variables	Texture du sol					
	Sandy-clay	Silty-loam	Sandy-loam	Means	F	p
Mortality rate, %	69±27^b	75±0^b	18±7^a	54±26	24.290	0.000
Plants height, cm	87.80±0.28^a	82.40±0.00^a	97.73±7.74^a	89.31±8.58	3.088	0.095
Stem girth at stump, cm	5.87±0.26^a	4.71±0.00^a	7.31±2.45^a	5.97±2.72	3.123	0.093
Stem girth at 1 m high, cm	1.89±0.00^a	1.89±0.00^a	3.60±3.61^a	2.26±3.25	0.539	0.601
Crown formation, %	30±14^{ab}	20±0^b	78±23^a	43±31	5.872	0.023
Crown radius, cm	30.40±4.81^a	26.40±0.00^a	36.58±5.66^a	31.13±6.16	2.217	0.165

The means on the same line affected by a same letter are not significantly different with ANOVA and Duncan test.

Table 5. Growth speed and water resources use by the young cocoa trees

Parameters	Annual elongation, $cm.an^{-1}$	Water use efficiency, $cm.m^{-3}$
Shading (%)		
[0-25[	56.00±3.12^a	5.15±0.29^a
[25-50[	62.27±6.05^a	5.73±0.56^a
[50-75[	69.40±9.66^a	6.39±0.89^a
[75-100[	71.53±6.27^a	6.58±0.57^a
Means	64.80±8.58	5.96±0.79
F	3.361	3.363
p	0.076	0.076
Soil depth (m)		
<0,8	59.95±9.64^b	5.52±0.89^b
0,8-1	62.76±3.69^b	5.78±0.34^b
>1	74.67±5.85^a	6.87±0.54^a
Means	65.79±8.58	6.06±0.79
F	4.555	4.555
p	0.043	0.043
Soil texture		
Sandy-clay	57.80±0.28^a	5.32±0.03^a
Silty-loam	52.40±0.00^a	4.82±0.00^a
Sandy-loam	67.73±7.74^a	6.24±0.71^a
Means	59.31±8.58	5.46±0.79
F	3.088	3.107
p	0.095	0.094

The means on the same line affected by a same letter are not significantly different with ANOVA and Duncan test

The soil depth has a significant impact on the water use efficiency ($F_{(8, 12)}$ = 4.555, p=0.043). As a result, the cocoa trees better use water when the soil is deeper. It is worth emphasizing the very strong correlation between the agronomic variables measured on the cocoa trees during the works. There is a very strong correlation ($0.84<r^2<0.87$) between the cocoa trees height and the stem girth at the stump, the stem girth at 1 m height, the crown formation and the crown radius. A strong correlation ($0.77<r^2<0.87$) also exists between the stem girth at the stump and at 1 m height and the formation crown then the crown radius. A strong correlation (r^2=0.89) also exists between the crown radius and the crown formation. Therefore, as each variable is changing this is translated into the change of all the other variables. This reflects the harmonious development of the cocoa trees whatsoever the replanting agroecosystem.

DISCUSSION

The cocoa trees mortality rate is higher than 10 % generally accepted. The rainfall has been particularly harsh during the study period. In average, the rainfall over the last six years in the area was around 1622±66 mm.year^{-1} while during the experiments, only 1211 mm.year^{-1} of rain were recorded. This explains the slightly higher mortality rate for the cocoa trees.
The study results revealed that the agroforestry trees shading actually affects the cocoa trees associated therewith. The denser was the shading, the more protected the cocoa trees were against the sun. This confirmed the works of Beer *et al*. (1998) who claimed that the presence of agroforestry trees on the cocoa farms reduced their stress by modulating the high and low temperature of about 5 °C. The high mortality of the cocoa trees under less denser shading confirmed the findings of Snoeck (2010) who described the need to associate the forest species with the cocoa trees for fear of destroying prematurely the plantations. But these results on shading refuted the works of Myers *et al*. (2000) who considered the cocoa trees agroforests as a threat to the biodiversity because they were part of the intensive production without shading. Actually, full-sun cocoa farming is strongly worst for the cocoa production sustainability (Tondoh *et al.,* 2015). It is allowed that the cocoa trees orchards associated with shading trees remain today, the only landscapes which better preserve biodiversity with native forest trees (Bhagwat *et al.,* 2008). Positive effects of shade trees on cocoa productivity are linked with the creation of an environment that improves cocoa crop physiology and reduces pressure of pests and diseases, rather than with the improvement of soil quality as a consequence of intercropping with trees (Vanhove *et al*., 2016).

It is essential to maintain or implant agroforestry trees in immature cocoa trees plantations like *Samanea saman, Albizia zygia, Terminalia superba* or *Khaya grandifoliola* and others timbers both for their shading and/or their fertility property (symbiotic nitrogen fixation). The number of species to be maintained depends on the forest trees age, provided that the shading coverage is complete (75-100% of shade regime). To obtain sufficient shading in a young plantation in full sunlight, it is essential to result to temporary shading similar to that of *Musa spp*. until the newly established forest tree species grow and develop their canopy. One hundred of forest trees at the beginning with thinning and cutting later, would allow the sufficient recovering of the young cocoa trees. These thinning are recommended when the cocoa trees reach their self-shading. The depth and texture of the soils under the cacao trees advised by Koko (2014), who proposed 1.5 m depth on sandy-loam soils, are confirmed by this study which found that the sandy-loam soils with a depth of 1 m at least are ready to contribute to the cocoa trees better growth.

The soil depth is essential as it impacts on the plant height, the annual elongation and the water use efficiency by the plant without forgetting all the correlations ($0.84<r^2<0.87$) existing between the different measured agronomic variables. A good deep soil will certainly ensure a faster and harmonious development of the cocoa trees. The works of Isaac *et al*. (2014) showed the importance of the sandy-loam soil texture for cocoa trees which develop in it a significant roots system especially in the presence of shade trees more than in the clay soil. The soil physical quality for cocoa trees must not lose sight of its chemical quality, especially as the soils fertility under the cocoa trees in Togo is also to question. There haven't been any mineral fertilizer recommendations for the cocoa trees in Togo and the soil fertility management is based on the agroforestry fertility trees. This reveals the importance of the agroforestry and the shading regulation in the cocoa trees agroforests in Togo.

Conclusion

The adaptability of the young cocoa trees to different replanting agroecosystems in Togo was examined through the test of the agronomic variables and use of water resources based on the shading density of the agroforestry trees in the cocoa trees orchards, the depth and the texture of the soil under the cocoa trees. It was found that the agroforestry trees shading density, the soil depth and texture had significant effects on the growth of the cocoa trees. The denser the shading was, the lesser the cocoa trees death, the more developed the cocoa trees crown and the larger the crown radius were. The deeper was the orchards soil, the better the rainwater use was by the cocoa trees and the faster they grow. A low death rate of the cocoa trees was reported when the soil texture was sandy-loam and the larger was the number of the crowns developed after a year growth. The young cocoa trees would better develop, if they were planted on sandy-loam soils with more than one meter deep and under shading capturing at least 75% of light. Therefore, it would be interesting to study the behaviour of these cocoa trees orchards when they start producing. The conservation of agroforestry trees just for shading in cocoa trees orchards would be an advantage not only for these agroforests sustainability but also for biodiversity conservation.

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