GLOBAL JOURNAL OF ENGINEERING, DESIGN & TECHNOLOGY
(Published By: Global Institute for Research & Education)
www.gifre.org

PRODUCTION CONSTRAINTS IN COCOA NURSERY IN SELECTED MAJOR COCOA PRODUCING AREAS IN GHANA

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Abstract

The study was carried out to identify major production constraints confronting establishment and rehabilitation of smallholder cocoa farms and its impacts on cocoa production. It was carried out by administering questionnaire and taking soil samples from five cocoa stations (Buako, Bunso, Kwadaso, Poano and Fumso) and six cocoa farming communities (Obuasi Nkwanta, Nyinahini, Akroso, Sefwi-Wiawso and Wassa-Akropong). Altogether one hundred and twenty farmers and five cocoa station officers were interviewed. The results revealed that the main constraints militating against the establishment and rehabilitation cocoa farms are poor soil nutrients, scarcity of early bearing and high yielding cocoa seeds and seedlings. Others are non-availability of appropriate cocoa nursing poly bags, inappropriate watering application rate at the nursery period and poor agro-chemical application technology. The study showed that about 68 % of cocoa farmers raised cocoa seedlings using drinking water sachets that are shorter than the recommended nursing poly bags and this may affect root development after four month in the nursery which may lead to poor establishment of seedlings after transplanting.

The soils in the study areas were deficient in soil macronutrients and the physical growth parameters of cocoa seedlings produced in the study areas were less vigorous compared to recommended seedlings by Cocoa Research Institute of Ghana which could be the consequence of nutrient deficiency. To correct nutrient deficiency and other challenges, it is recommended that farmers have to adopt the use of organic and inorganic fertilizers, use appropriate nursery bags and use adequate watering regime for nursing seedlings.

Key Words: *Soil chemical properties, cocoa seedlings, nursery poly bags and cocoa farmer.*

Introduction

Cocoa (*Theobroma cacao L*) is an important cash crop and a major source of income to many smallholder farmers in the Forest region of West Africa. Presently the global cocoa production is estimated at 9.3 million tons and has been rising fairly steadily over the past ten years fueled by increasing production in the Côte D'Ivoire and Ghana as well as the ever-increasing production within a decade in Indonesia (FAO, 2009). It is estimated that 90 % of worldwide cocoa production comes from smallholdings (ICCO, 2006; Donald, 2004) and most of this production occurs in areas of high biodiversity (Anglaaere, 2005).

West Africa is currently leading in world cocoa production with about 70 %, while Asia and the Americas contribute about 16 % and 14 %, respectively (Anim-Kwapong, 2006). Ghana is currently the second largest producer of cocoa beans in the world (ICCO, 2007) with present production over 989,000 metric tons on an estimated total cultivation area of over 1.6 million hectares and over two million farmers presently engaged in the sector. In Ghana, planting and replanting of cocoa farms has been a tool for sustainable cocoa production. Despite the positive role played by smallholder cocoa farmers in the establishment and rehabilitation of cocoa farms, cocoa cultivation is still limited by production difficulties resulting in the low production per hectare (200 -700 kg/ ha) compared to optimum yield of 800 - 1000 kg/ ha (Asare, 2008; Alfred, 2009). As much as 40 % of cocoa farmers are not producing at the optimum in Ghana. It is therefore necessary to investigate the major production constraints confronting the establishment and rehabilitation of smallholder cocoa farms and its impacts on cocoa production in the major cocoa growing areas of Ghana and make appropriate recommendations.

Materials and Methods

The methods used for this study include survey using questionnaire and taking soil samples for chemical analysis. This was carried out across the major cocoa growing areas in the country.

Field Survey

Data from field survey was obtained using structured questionnaire administered to two sets of stakeholders. A set was administered to five senior technical officers who are in charge of selected cocoa nursery stations (i.e Buako station in Western region; Bunso station in Eastern Region; Kwadaso station, Poano station and Fumso in Ashanti Region). The second set of questionnaire was administered to 120 randomly selected cocoa farmers from five cocoa growing communities (i.e Obuasi Nkwanta and Nyinahini in Ashanti Region; Akroso in Eastern Region; Sefwi-Wiawso and Wassa-Akropong in Western Region).The areas were selected based on their high cocoa production and soils suitable for cocoa production. Fifty cocoa seedling plants at 5 months after planting (5MAP) were selected at random from each cocoa station and 20 cocoa seedling plants at same age from five individual farmers in each community were tagged. The plant height, leaf area, number of leaves and stem girth were measured. Plant height and leaf area were measured using a measuring tape. The plant height was taken from the soil surface to the apical tip of the plant. The leaf length and breadth were measured. The leaf area was estimated by multiplying the product of length and maximum width by 1.396 cocoa leaf calibration factors (Amanpongni, 2011). The plant stem girths were measured by putting a string around the stem and the length then measured using veneer calipers. Data collected were analyzed using descriptive statistics for Statistical Package for Social Science (SPSS) to estimate the percentage response and mean values (Steel *et al.*, 1997).

Field Soil Sampling

In each study region, soil samples were collected from both cocoa farms of individual farmers and plantations of cocoa stations. Sampled farms belonged to farmers predominantly engaged in nursing of seedlings. In all, 30 soil samples were collected across the five cocoa growing communities and five cocoa stations (i.e three samples from each cocoa station and three samples from each community). Soil samples were taken at 0 - 45cm soil depth using soil auger and earth chisel. The soil samples were air-dried and sieved using a 2 mm sieve and analyzed for pH, N, P, K, CEC and organic carbon at the Soil Research Institute of CSIR, Kwadaso - Kumasi.

Soil pH of 1:1 soil-water ratio was measured using an EDT BA 350 digital pH meter while organic carbon was determined by the wet digestion dichromate acid-oxidation method. Total N was determined using Kjeldahl digestion method and available P by Bray P1 method. Exchangeable cations ($Ca^{2+,}$ Mg^{2+}, K^{+} and Na^{+}) were extracted with 1 N ammonium acetate (NH4OAc) buffered at pH 7.0 . Exchangeable K and Na in the extracts were read through the Jenway flame photometer (model PFP7) and Ca and Mg were read on Atomic Absorption Spectrophotometer (AAS).

Results and Discussion

Hybrid Cocoa Pods and Poly Bags

Table 1 presents the sources of hybrid cocoa pods and type of poly bags used in raising hybrid cocoa seedlings by both cocoa farmers and cocoa stations.

Table 1: Sources of hybrid cocoa pods and poly bags

	Sources of Hybrid cocoa seeds			**Type of Poly bags**	
	CFF	SPU	both	COCOABOD	WS
Cocoa stations	0.0	100.0	-	90.0	10.0
Cocoa farmers	45.0	54.2	0.8	31.2	68.8

CFF: Cocoa farmers farm SPU: Seed production unit WS: Water sachets

The study revealed that the seed production unit (SPU) and cocoa farmer's farm (CFF) are the only sources of hybrid cocoa seeds for raising hybrid cocoa planting seedlings and planting direct in the three major cocoa growing regions in Ghana. The study also revealed that the SPU produced an average of 3.5 million hybrid cocoa pods annually which is inadequate to meet the current demand of 18.9 million hybrid cocoa pods (Asare, 2008). This situation has compelled 45 % of farmers to harvest their own cocoa pods for sowing to raise cocoa seedlings which turn out to be late bearing, fewer pods per plant, small bean sizes, fewer beans per pod and seedlings less resistant to pests and diseases.

Water sachets (12 cm x 14 cm) (68.8 %) and cocoabod poly bags (13 cm x 18 cm, 12 cm x 18 cm and 15 cm x 20 cm) (31.2 %) are the main types of poly bags used by the cocoa farmers in the three regions in raising cocoa seedlings. The high usage of water sachets in Ghana is due mainly to non-availability of cocoabod poly bags but not the cost. Water sachets used in raising cocoa seedlings is currently not only by the cocoa farmers but also the cocoa stations which may affect root development after four month in the nursery which may lead to poor establishment of seedlings after transplanting (Famuwagun&Agele,2010).

Chemical Properties of Soils

Cocoa stations	Region	pH	Exchangeable Cations (cmol/kg)			CEC	Percentage (%)			
			Ca	Mg	Na		N	K	P	OC
Fumso	Ashanti	5.7	3.7	1.3	0.1	5.1	0.2	47.2	3.7	11.8
Kwadaso	Ashanti	5.6	5.0	0.6	0.1	5.2	0.3	20.7	2.5	10.4
Buako	Western	5.7	4.5	1.6	0.1	7.0	0.3	10.3	7.4	1.6
Bunso	Eastern	6.0	7.0	1.5	0.1	8.9	0.3	39.2	6.4	15.2
Poano	Ashanti	5.7	4.9	1.3	0.1	5.0	0.3	25.5	3.5	11.3
LSD(0.05)		**0.3**	**2.4**	**0.6**	**0.0**	**3.4**	**0.2**	**29.4**	**4.2**	**10.2**

The pH value of Bunso cocoa station recorded the highest mean value of 6.0 which is slightly acidic and good for normal cocoa production (Alloway, 1996; Ogunrinde, 2006) but below the soil pH of 6.5 required for optimum cocoa production (Thong & Ng, 1978). Low pH value of 5.6 such as at Kwadaso, according to Thong & Ng (1978) may lead to increase in exchangeable aluminium that may restrict uptake of nutrients and inhibit root development of cocoa plant and hence crop yield. Bunso and Kwadaso cocoa stations had the moderate mean calcium concentration above the 5 cmol/kg required for cocoa production. The current IFDC report (IFDC, 2010) on nutrient assessment of some selected cocoa plantations in Ghana, showed similar calcium trend. Hence, the applications of calcium fertilizers are necessary on Fumso, Boako and Poano soils to facilitate the growth of roots, roots hairs, root tips, meristems of cocoa plants and control the toxicity of aluminium, sodium, manganese and magnesium irons in the soils for optimal yield.

All the cocoa stations had mean magnesium content higher than the critical level of 0.15 cmol/kg but lower than the optimum level of 3.0 cmol/kg (Thong and Ng, 1978) and this may cause whitening of tissue between leaf veins and chlorosis in leaves of cocoa leaves (Hartemink, 2005).

The sodium from the various cocoa stations was low which may lead to stunted roots, root hairs and terminal buds in cocoa production (Ling, 1990; Greenland, 1994). The potassium values obtained from the stations were below the critical value of 50 % except soils from Buako cocoa station. The low potassium content recorded in Fumso, Bunso, Kwadaso and Poano may delay the rate of photosynthesis and formation of chlorophyll in cocoa plant that may also affect the formation of leaves and fruits (Plucknett and Sprague, 1989; Raja Harun & Hardwick, 1986). It is therefore necessary to apply potassium fertilizer to the soils deficient in potassium such as those from Fumso, Bunso, and Kwadaso Poano for optimal yield. The cation exchange capacity of the soils from all the cocoa stations was below the critical level of 10 $cmolkg^{-1}$ required for cocoa production (Thong & Ng, 1978).

Nitrogen content of all the investigated soils was adequate for cocoa production since all the values were higher than the critical value of 0.09 % (Aikpokpodion, 2010). The high nitrogen content recorded in all the soils may aid in regulating the cocoa plants ability to utilize phosphorous and potassium which facilitate the green pigmentation of cocoa seedlings which is the primary absorber of light energy responsible for photosynthesis, stimulate the rapid and vigorous vegetative growth, improve seedlings height and dark green color seedling leaves (Ogunrinde, 2006; Bergmann, 1992).

The available phosphorus in soils from all the selected cocoa stations was lower than the critical value of 10 % (Aikpokpodion, 2010). The low phosphorus content in soils for cocoa in Ghana especially Western and Central Regions has also been reported by IFDC (2010). Low phosphorous content retards the formation of roots, flowers, fruits and seeds and makes the plant less resistance to diseases which eventually reduce plant yield (Ling, 1990; Holford, 1997).

Organic carbon content recorded from plantation of the various cocoa stations was adequate for cocoa production (Hartemink, 2003). The high organic carbon content is the true reflection of the adequate nitrogen content which improves the carbon/nitrogen ratio in the soil.

Table 3 presents the chemical properties of soils from selected cocoa growing communities used in raising hybrid cocoa seedlings by cocoa farmer.

Table 3: Chemical properties of soils from selected cocoa growing communities

Town	Region	pH	Exchangeable Cations (cmol/kg)			CEC	Percentage (%)			
			Ca	Mg	Na		N	K	P	OC

Akroso	Eastern	6.2	2.5	0.2	0.1	2.9	0.2	10.0	2.9	27.6
Sefwi Wiawso	Western	5.3	5.7	3.5	0.1	0.3	0.3	9.7	64.4	2.3
Nyinahini	Ashanti	6.2	7.8	1.3	0.1	0.4	0.4	9.5	93.7	9.3
Obuasi Nkwanta	Ashanti	5.7	3.1	0.9	0.1	0.1	0.3	4.2	40.6	6.9
Wassa Akropong	Western	6.2	5.7	1.3	0.1	0.3	0.3	8.5	62.4	9.1
LSD(0.05)		0.8	4.3	2.4	0.0	2.4	0.2	4.8	67.4	19.4

Generally, the soils were slightly acidic and are low for cocoa cultivation (Alloway, 1996; Ogunrinde, 2006) that is below the recommended pH value of 6.5 for optimum cocoa production (Thong & Ng, 1978). Nyinahini and Sefwi Wiawso cocoa farms had moderate soil calcium concentration more than 5 cmol/kg need for cocoa production (SRI, 1990). The low trend of calcium values in most cocoa farms is similar to that reported by IFDC (2010) on nutrient assessment of some selected cocoa plantations in Ghana, showed similar calcium trend. Hence, the applications of calcium fertilizers are necessary on these soils. Akroso, Sefwi Wiawso and Nyinahini cocoa farms had magnesium content higher than critical value of 0.15cmol/kg (Paramananthan, 2006). All the cocoa farms had magnesium content lower than the optimum value of 3. 0cmol/kg and this may lead to whitening of tissue between leaf veins and chlorosis in leaves of cocoa leaves (Hartemink, 2005).

The sodium content of the soil from all selected cocoa farms were low, consequently may contribute to stunted root tips, root hairs and terminal buds in cocoa production. The K values obtained from the Akroso and Obuasi Nkwanta farms were below the critical level of 50 % required for cocoa cultivation (SRI, 1990) which may lead to delay of photosynthesis and formation of chlorophyll in cocoa plant, holding up or delay the formation of leaves and fruits (Plucknett & Sprague, 1989).

The cation exchange capacity of the soils from all the cocoa farms was lower than the critical level of 10 cmol/kg required by cocoa plant (Thong & Ng, 1978; SRI, 1990). All the values obtained from the various cocoa farms were low which may restrict uptake of nutrients (Holford, 1997; Hartemink, 2005).

Nyinahini farms had the highest nitrogen concentration of 0.4 % followed by Sefwi Wiawso, Wassa Akropong, Obuasi Nkwanta and Akroso in decreasing order. Nitrogen content of soils sampled from all the cocoa communities was adequate for cocoa production since all the values were higher than the critical value of 0.09 % (Aikpokpodion, 2010) which promote vegetative growth of plant, formation of plant tissues and aid in the plants ability to use phosphorous, potassium and other nutrients (Ling, 1990).

The available phosphorus obtained from all the selected cocoa farms was lower than the critical level 10 % (Aikpokpodion, 2010) and this situation may retard the formation of roots, flowers, fruits and seeds. The plants also become less resistance to diseases which eventually reduced plant yield (Alfred, 2009).

Organic carbon content of soils sampled from all the cocoa communities was adequate for cocoa production since all the values were higher than the optimum value of 4.0 % (Paramananthan, 2006) which aid in the cocoa plants ability to utilize phosphorous, potassium and other nutrients. The mean value of nitrogen, potassium, calcium, sodium, magnesium content of soils obtained from selected farming communities and the cocoa stations were almost the same (P = 0.05) but were below the recommended values for cocoa production in Ghana except for nitrogen and organic carbon (Thong & Ng, 1978; Wessel (1987) and (Paramananthan, 2006). Also mean values of pH, phosphorous, CEC and organic carbon obtained from selected farming communities were higher than the cocoa stations but lower than the recommended values.

Physical Growth Parameters of Hybrid Cocoa Seedlings

Table 4: Mean growth parameters of hybrid cocoa seedlings from selected cocoa stations at 5 MAP

Cocoa farms	Region	Number of leaf	Leaf area (cm^2)	Plant height(cm)	Stem girth (cm)

Buako	Western	9.8	132.9	29.9	1.9
Bunso	Eastern	11.0	134.8	28.1	1.9
Fumso	Ashanti	9.6	128.3	30.1	2.0
Kwadaso	Ashanti	9.8	136.2	29.2	2.4
Poano	Western	9.9	132.1	29.7	2.0
LSD(0.05)		1.1	6.0	1.6	0.4

Seedlings at Bunso cocoa station had the highest number of mean leaf of 11.0. However the numbers of leaves were lower compared to 15 expected at 5MAP. The low number of leaves may have been caused by the low concentration of calcium, potassium and nitrogen in the soil.

Seedlings at Kwadaso cocoa station had the highest mean leaf area of 136.2 cm^2. Fumso recorded the least mean leaf area of 128.3 cm^2. All the values obtained from the selected cocoa stations were lower than the optimum value of 250.0 cm^2 required for vigorous hybrid cocoa seedlings and low soil nutrient may be the possible cause (Hartemink, 2003).

Mean plant height of seedling from cocoa stations was on the average of 29.4 cm. Fumso cocoa Table 5 presents the growth parameters of hybrid cocoa seedlings from selected cocoa growing communities.

station recorded the highest mean plant height of 30.1 cm followed by Buako of 29.9 cm while Bunso recorded the least mean plant height of 28.1 cm. The values obtained from selected stations were below the optimum value of height of 35 cm required for vigorous hybrid cocoa seedlings for planting (Shepherd, 1978). The low level of magnesium, calcium, potassium, and phosphorus recorded in the soils used for nursery at cocoa stations may have resulted in stunted growth.

Mean seedling stem girth obtained from cocoa stations were below the optimum value of 2.5 cm required for vigorous hybrid cocoa seedlings (Shepherd, 1978) and this may be caused by low level of potassium and phosphorus observed in the soil (Bergmann, 1992).

Table 5: Physical Growth Parameters of Hybrid Cocoa Seedlings from selected cocoa growing communities at 5 MAP

Cocoa farms	Region	Number of leaf	Leaf area (cm^2)	Plant height(cm)	Stem girth (cm)
Akroso	Eastern	9.8	104.3	26.2	2.0
Obuasi Nkwanta	Ashanti	9.9	102.8	27.2	2.0
Bunso	Eastern	9.9	108.8	26.1	1.9
Nyinahini	Ashanti	9.9	97.8	26.1	1.9
Sefwi Wiawso	Western	9.8	108.4	26.4	1.9
Wassa Akropong	Western	10.2	104.9	28.5	1.9
LSD(0.05)		0.3	8.0	1.9	0.1

Cocoa seedlings at Wassa-Akropong had the highest mean number of leaves of 10.2 with the least mean number of leaf of 9.8 recorded at Akroso. The number of leaves from all selected farms was lower than the optimum value required

Cocoa seedlings at Bunso had the highest mean leaf area of 108.8 cm^2. Cocoa seedlings at Nyinahini had the least mean leaf area of 97.8 cm^2. The leaf area at all surveyed communities were lower than the optimum value of 250 cm^2.

Bunso farms had the highest mean plant height of 29.0 cm. Akroso recorded least mean plant height of 26.1 cm. Seedling height at all five sites were below the optimum value of height of 35 cm. Obuasi Nkwanta had the highest mean plant stem girth of 2.0 cm followed by Akroso. Nyinahini recorded least mean plant stem girth of 1.9 cm.

for vigorous hybrid cocoa seedlings. These observations also confirmed early study by Plucknett and Sprague (1989) and Hartemink (2003) that deficiencies in magnesium and phosphorus in the soils affects the formations of leaves by cocoa plant.

Stem girth at all the selected farms were below the optimum value of 2.5 cm (Shepherd, 1978) and this may have been caused by low level of potassium, magnesium and phosphorus observed in the soils. This gives credence to the work done by Hartemink (2005), Ogunlade and Aikpokpodion (2006) that low levels of potassium and phosphorous concentration in the soil tends to produce thin stem diameter of cocoa plant.

Table 6: Comparison of Growth parameters of cocoa seedlings from the selected plantations of cocoa stations and cocoa growing communities

	Growth parameters			
	Number of leaf	Leaf area (cm^2)	Plant height(cm)	Stem girth (cm)
Cocoa stations	10.0	133.0	29.0	2.0
Cocoa communities	9.5	105.0	27.0	1.9
LSD(0.05	0.6	39.6	2.8	0.1

The mean values of number of leaf and stem girth obtained from selected farming communities and the cocoa stations were similar (P = 0.05). Leaf area and plant height from cocoa stations were higher than the seedlings from cocoa farming communities (P = 0.05). All the mean values of growth parameters had in both cocoa stations and selected cocoa farming communities (Table 6) were below the recommended values for cocoa production (Teoh, 1980 and Shepherd, 1978) which may have been caused by low level of soil nutrients with the consequence reduction cocoa production in future.

Conclusion

The study revealed that the major production constraints militating against cocoa establishment and rehabilitation by smallholder cocoa farmers are inadequate hybrid cocoa pods, non availability of nursery poly bags, poor soil nutrients and poor seedlings vigor. It was evident that the investigated soils were adequate in nitrogen and organic carbon content but deficient in potassium, phosphorous, sodium, calcium, magnesium and exchangeable cations capacity in the soils used for seedling production at both cocoa stations and cocoa farmers in the three regions.

The growth parameters (height, leaf area, leaf number and stem girth) of hybrid cocoa seedlings in the study area were less vigorous which could be the consequence of nutrient deficiency in the soils. However those from cocoa stations were better in terms of leaf area and plant height and may therefore result in better yield and are therefore recommend. In general the soils used for nursery have to be improved in terms of fertility to give more vigorous seedlings for better yield.

Acknowledgements

We are grateful to the Cocoa Research Institute of Ghana (CRIG) and Directors and staff of all the sample cocoa stations of Ghana Cocoa Board for providing fields for this study. Our sincere gratitude goes also to the Directors and staff of CSIR - *Soil Research Institute* (SRI), Kumasi for providing laboratory for analysis.

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